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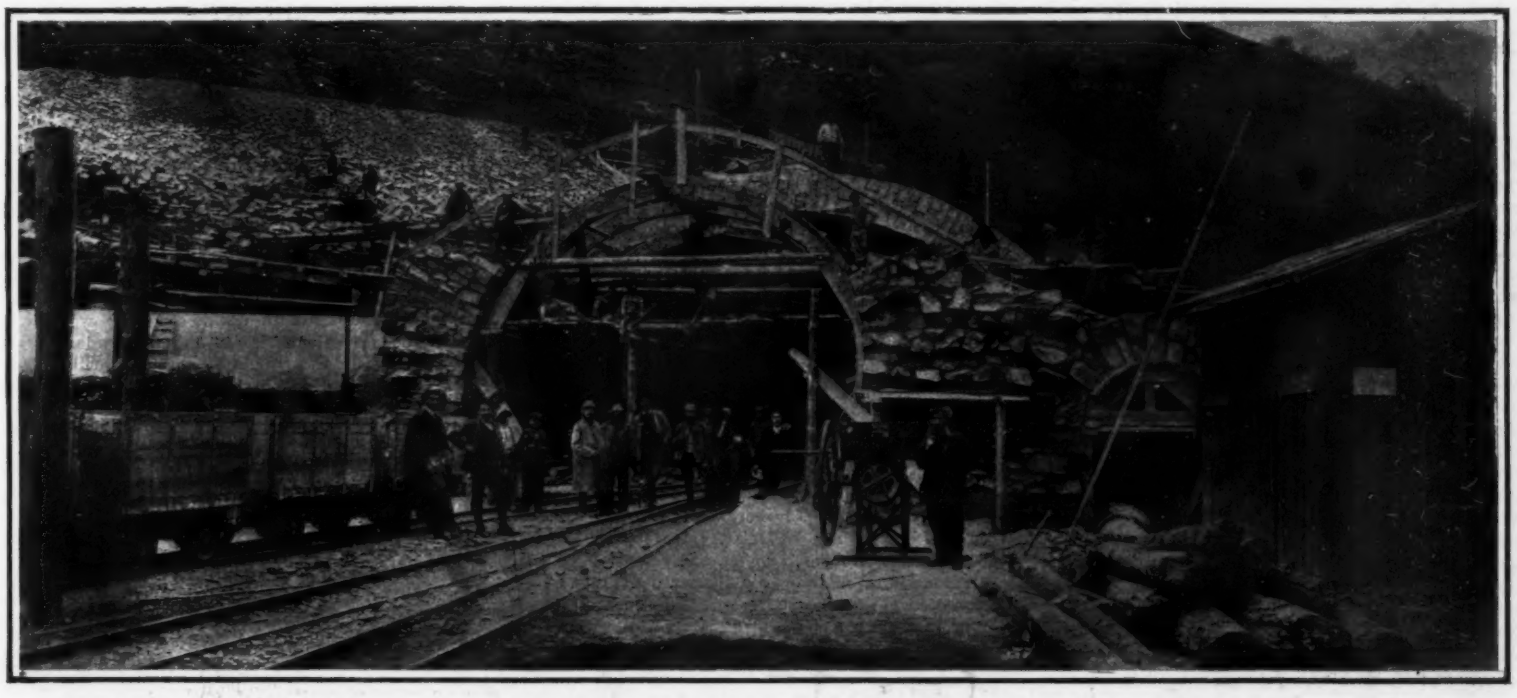


SOUTH PORTAL OF THE LOETSCHBERG TUNNEL UNDER THE BERNESE ALPS. THE MACHINE SHOPS, ENGINE ROOM, POWDER HOUSES, AND STORES ARE LOCATED WITHIN A FEW HUNDRED FEET OF THIS PORTAL.

HAULING ONE OF THE TUNNEL-VENTILATING BLOWERS UP THE MOUNTAIN PATHS LEADING TO GOPPENSTEIN. IT WAS TOO LARGE TO BE TAKEN THROUGH THE SMALL TUNNELS ON THE CONSTRUCTION LINE.

THE LOETSCHBERG TUNNEL THROUGH THE BERNESE ALPS.—[SEE PAGE 296.]

THE ORIGIN OF LIFE.*

A DISCUSSION OF MODERN VIEWS.

BY PROF. E. H. STARLING.

A LIVING organism may be regarded as a highly unstable chemical system which tends to increase itself continuously under the average conditions to which it is subject, but undergoes disintegration as a result of any variation from this average. The essential condition for the survival of the organism is that any such disintegration shall result in so modifying the relation of the system to the environment that it is once more restored to the average in which assimilation can be resumed.

We may imagine that the first step in the evolution of life was taken when, during the chaotic chemical interchanges which accompanied the cooling down of the molten surface of the earth, some compound was formed, probably with absorption of heat, endowed with the property of polymerization and of growth at the expense of surrounding material. Such a substance could continue to grow only at the expense of energy derived from the surrounding medium, and would undergo destruction with any stormy change in its environment. Out of the many such compounds which might have come into being, only such would survive in which the process of exothermic disintegration tended toward a condition of greater stability, so that the process might come to an end spontaneously and the organism or compound be enabled to await the more favorable conditions necessary for the continuance of its growth. With the continued cooling of the earth, the new production of endothermic compounds would probably become rarer and rarer. The beginning of life, as we know it, was possibly the formation of some complex, analogous to the present chlorophyl corpuscles, with the power of absorbing the newly penetrating sun's rays and of utilizing these rays for the endothermic formation of further unstable compounds. Once given an unstable system such as we have imagined, with two phases, viz. (1) a condition of assimilation or growth by the endothermic formation of new material; (2) a condition of "exhaustion," in which the exothermic destructive changes excited by unfavorable external conditions came to an end spontaneously—the great principle of natural selection or survival of the fittest would suffice to account for the evolution of the ever-increasing complexity of living beings which has occurred in the later history of this globe. The adaptations, i. e., the reactions of the primitive organism to changes in its environment, must become continually more complex, for only by means of increasing variety of reaction can the stability of the system be secured within greater and greater range of external conditions. The difference between higher and lower forms is therefore merely one of complexity of reaction.

The naked protoplasm of the plasmodium of Myxomycetes, if placed upon a piece of wet blotting paper, will crawl toward an infusion of dead leaves, or away from a solution of quinine. It is the same process of adaptation, the deciding factor in the struggle for existence, which impels the greatest thinkers of our time to spend long years of toil in the invention of the means for the offense and defense of their community or for the protection of mankind against disease and death. The same law which determines the downward growth of the root in plants is responsible for the existence to-day of all the sciences of which mankind is proud.

The difference between higher and lower forms is thus not so much qualitative as quantitative. In every case, whatever part of the living world we take as an example, we find the same apparent perfection of adaptation. Whereas, however, in the lower forms the adaptation is within strictly defined limits, with rise in type the range of adaptation steadily increases. Especially is this marked if we take those groups which stand, so to speak, at the head of their class. It is therefore important to try to find out by a study of various forms the physiological mechanism or mechanisms which determine the increased range of adaptation. By thus studying the physiological factors, which may have made for success in the struggle for dominance among the various representatives of the living world, we may obtain an insight into the factors which will make for success in the further evolution that our race is destined to undergo.

It is possible that, even at this time, objections may be raised to the application to man of conclusions derived from a study of animals lower in the scale. It has indeed been urged, on various grounds, that man is to be regarded as exempt from the natural laws which apply to all other living beings. When we inquire into the grounds for assuming this anomic, this outlawed condition of man, we generally meet with the argument that man creates his own environment and cannot therefore be considered to be in any way a product of it. This modification or creation of environment is, however, but one of the means of adaptation employed by man in common with the whole living kingdom. From the first appearance of life on the globe we find that one of the methods adopted by organisms for their self-preservation is the production of some artificial surroundings which protect them from the buffeting of environmental change. What is the mucilaginous envelope produced by microorganisms in presence of an irritant, or the cuticle or shell secreted by the outermost cells of an animal, but the creation of such an environment? All unicellular organisms, as well as the units composing the lowest metazoa, are exposed to and have to resist every change in concentration and composition of the surrounding water. When, however, a body cavity or *cœlom*, filled probably at first with sea water, made its appearance, all the inner cells of the organism were withdrawn from the distributing influence of variations in the surrounding medium. The cœlomic fluid is renewed and maintained uniform in composition by the action of the organism itself, so that we may speak of it as an environment created by the organism. The formation of a body cavity filled with salt solution at once increased the range of adaptation of the animals endowed therewith. Thus it enabled them to leave the sea, because they carried with them the watery environment which was essential for the normal activity of their constituent cell units. The assumption of a terrestrial existence on most parts of the earth's surface involved, however, the exposure to greater ranges of temperature than was the case in the sea, and indicated the necessity for still further increase in the range of adaptation. Every vital process has its optimum temperature at which it is carried out rapidly and effectively. At or a little above freezing point the chemical processes concerned in life are suspended, so that over a wide range of the animal kingdom there must be an almost complete suspension of vital processes during the winter months, and at all times of the year a great dependence of the activity of these processes on the surrounding temperature. It is evident that a great advantage in the struggle for existence was gained by the first animals which succeeded in securing thermal as well as chemical constancy of environment for their cells, thus rendering them independent of changes in the external medium. It is interesting to note that the maintenance of the temperature of warm-blooded animals at a constant height is a function of the higher parts of the central nervous system. An animal with spinal cord alone reacts to changes of external temperature exactly like a cold-blooded animal, the activity of its chemical changes rising and falling with the temperature. In the intact mammal, by accurately balancing heat loss from the surface against heat production in the muscles, the central nervous system insures that the body fluid which is supplied to all the active cells has a temperature which is independent of that of the surrounding medium. These are fundamental examples of adaptation effected by creation of an environment peculiar to the animal. Numberless others could be cited which differ only in degree from the activity of man himself. In some parts of this country, for instance, the activity of the beaver in creating an artificial environment has until lately been more marked than that of man himself. We are not justified, then, in regarding mankind as immune to the operation of natural forces which have determined the sequence of life on the surface of the globe. The same laws which have determined his evolution and his present position, as the dominant type on the earth's surface will determine also his future destiny.

We are not, however, dealing with or interested in simple survival. Lower forms of life are probably as abundant on the surface of the globe as they were at any time in its history. Survival, as Darwin pointed out, is a question of differentiation. When in savage warfare a whole tribe is taken captive by the victorious enemy, the leaders and fighting men will be destroyed, while the slaves will continue to exist as the property of the victors. Survival, then, may be determined either by rise or by degradation of type. Success involves the idea of dominance, which can be secured only by that type which is the better endowed with the mechanisms of adaptation required in the struggle against other organisms.

Among the many forms of living matter which may have come into being in the earlier stages of the history of the earth, one form apparently became predominant and must be regarded as the ancestor of all forms of life, whether animal or vegetable, viz., the nucleated cell. The almost complete identity of the phenomena involved in cell division throughout the living kingdom indicates that all unicellular organisms and all organisms composed of cells have descended from a common ancestor, and that the mode of its reproduction has been impressed upon all its descendants throughout the millions of years which have elapsed since the type was first evolved. The universal distribution of living cells renders it practically impossible for us to test the possibility of a spontaneous abiogenesis or new formation of living from non-living matter at the present time. We cannot imagine that all the various phenomena which we associate with life were attributes of the primitive life stuff. Even if we had such stuff at our disposal, it would be difficult to decide whether we should ascribe the possession of life to it, and there is no doubt that any such half-way material would, directly it was formed, be utilized as pabulum by the higher types of organism already abounding on the globe.

INTEGRATION AND DIFFERENTIATION.

An important step in the evolution of higher forms was taken when, by the aggregation of unicellular organisms, the lowest metazoon was formed. In its most primitive forms the metazoon consists simply of a cell colony, but one in which all individuals are not of equal significance. Those to the outer side of the mass, being exposed to different environmental advantages from those within, must even during the lifetime of the individual have acquired different characteristics. Moreover, the sole aim of such aggregation being to admit of co-operation by differentiation of function between the various cell units, the latter become modified according to their position, some cells becoming chiefly alimentary, others motor, and others reproductive. Co-operation and differentiation are, however, of no use without co-ordination. Each part of the organism must be in a position to be affected by changes going on in distant parts, otherwise co-operation could not be effected. This co-operation in the lowest metazoon seems to be carried out by utilization of the sensibility to chemical stimuli already possessed by the unicellular organism. We have thus co-ordination by means of chemical substances ("hormones") produced in certain cells and carried thence by the tissue fluids to other cells of the body, a mechanism of communication which we find even in the highest animals, including man himself. To such chemical stimuli we may probably ascribe the accumulation of wandering mesoderm cells—i. e., phagocytes—in an organism such as a sponge, around a seat of injury or any foreign substance that has been introduced. By this mechanism it is possible for distant parts of the body to react to stimulation of any one part of the surface. Communication by this means is, however, slow, and may be compared to the state of affairs in civilized countries before the invention of the telegraph, when messengers had to ride to different parts of the kingdom in order to arouse the whole nation for defense or attack.

FORESIGHT AND CONTROL.

Increased speed of reaction and therefore increased powers in the struggle for existence were obtained when a nervous system was formed, by a modification of the cells forming the outer surface of the organism. By the growth of long processes from these cells a conducting network was provided, running through all parts of the body and affording a channel for the rapid propagation of excitation from the surface to the deeper parts, as well as from one part of the surface to another. From this same layer were produced the cells which, as muscle fibers, would act as the motive mechanism for the organism. Thus, from the beginning, the chief means of attack or escape were laid down in close connection with the surface from which the stimuli were received. A further step in the evolution of the nervous system consisted in the withdrawal of certain of the sensory or receptor cells from the surface, so that a specially irritable organ, the central nervous system, was evolved, which could serve as a distributing center for the messages or calls to action initiated by changes occurring at the surface of the body. At its first

* Abstracted from a paper read before the British Association for the Advancement of Science.

appearance this central nervous system would hardly deserve the epithet of "central," since it formed a layer lying some distance below the surface, and extending over a considerable area; though we find that very soon there is an aggregation of the special cells to form ganglia, each of which might be regarded as presiding over the reactions of that part of the animal in which it is situated. Thus in the segmental wormlike animals a pair of ganglia is present in each body segment, and the chain of ganglia are united by longitudinal strands of nerve fibers to form the ganglionated cord, or central nervous system.

Such a diffused nervous system, in which all ganglia were of equal value, could, however, only act for the common weal of the whole body when a reaction initiated by stimulation at one part was not counteracted by an opposing reaction excited from another part of the surface. For survival it is necessary that in the presence of danger, i. e., an environment threatening the life of the individual or race, the whole activities of the organism should be concentrated on the one common purpose, whether of escape or defense. This could be effected only by making one part of the central nervous system predominant over all other parts, and the part which was chosen for this predominance was the part situated in the neighborhood of the mouth. This, in animals which move about, is the part which always precedes the rest of the body, and therefore the part which first experiences the sense impressions, favorable or dangerous, arising from the environment. It is this end that has to appreciate the presence or approach of food material, as well as the nature of the medium into which the animal is being driven by the movements of its body. Thus a predominance of the front end of the nervous system was determined by the special development at this end of those sense organs or sensory cells which are *projicient*—i. e., are stimulated by changes in the environment proceeding from disturbances at a distance from the animal. The sensory organs of vision and the organs which correspond to our olfactory sense organs and are aroused by minute changes in chemical composition of the surrounding medium, are always found especially at the front or mouth end of the organism. The chances of an animal in the struggle for existence are determined by the degree to which the responses of the animal to the immediate environment are held in check in consequence of stimuli arising from approaching events. The animal, without power to see or smell or hear its enemy, will receive no impulse to fly until it is already within its enemy's jaws. It must therefore be an advantage to any animal that the whole of its nervous system should be subservient to those ganglia or central collections of nerve cells which are in direct connection with the projicient sense organs in the head. This subservience is secured by endowing the head center with a power, first, of controlling and abolishing the activities (i. e., all those aroused by external stimuli) of all other parts of the central nervous system, and, secondly, of arousing these parts to a reaction immediately determined by the impression received from the projicient sense organs of the head and originated by some change in the surroundings of the animal which has not yet affected the actual surface of its body.

THE MICROSCOPE.*

ITS PRACTICAL APPLICATIONS.

BY J. E. BARNARD.

AMONG scientific instruments, the microscope is at the present time one of the most extensively employed, either for commercial or scientific purposes. In nearly all branches of science it has now become a necessity, both as an essential factor in preliminary training and for advanced investigations or pure research work, while in commerce its uses are so wide and varied that it is difficult to see to what practical purposes it may not sooner or later be applied.

That this is the case may be due to many causes, and a by no means negligible factor is the simplification in construction and design that has in recent years been effected in the mechanical portions of the instrument and in its essential optical parts. In this respect, perhaps, a microscope differs from the majority of scientific instruments, as in most of the latter elaboration of construction—often, it must be admitted, quite unavoidable—is the usual rule; but for general purposes microscopes were never more simple in design than at the present time. This simplicity has not been obtained at the expense of loss of efficiency, but rather the contrary. The cost, too, has been greatly reduced, so that unless objectives and other optical parts of the highest class are required, a complete microscopic outfit may now be obtained of good quality and of high efficiency for a few pounds. The same, however, can scarcely be said if objectives of the finest quality are required, but this is rarely necessary for commercial purposes or for laboratory use unless work of a highly critical nature is to be carried out.

In our present state of knowledge it may almost be said that the science and practice of microscopic optics has reached such a stage of perfection that it is difficult to foretell in which direction the next improvement is to be looked for, much less the means by which such may be effected. Attempts have been made to increase optical efficiency, particularly by various dark-ground illumination methods, but it must be confessed with somewhat disappointing results. While such methods assist in demonstrating the presence of particles or isolated objects not easily seen, or even invisible by other means, the resolving power of the optical system is not improved. The most promising development has been in the apparatus introduced by Messrs. Carl Zeiss for use with ultra-violet light. This certainly held out a prospect of definite increase in resolving power being obtained, and in some directions has probably justified its existence. For the ordinary worker, however, the great cost of the necessary appliances, the more than usual skill required in its manipulation, the necessity of using special mounting materials, as well as the impossibility of observing any object mounted in the ordinary way on glass, has prevented its use for any but very special purposes.

For a long time a form of microscope stand, known as the Continental model, in which the instrument was supported on a foot of a horseshoe shape, practically held the field; but English makers, fortunately, to a large extent maintained their more stable method of support by means of a tripod foot. The latter not only admits of the microscope body being more conveniently swung, but also insures that at any inclination of the body-tube the center of gravity of the instrument is well within the triangle formed by the three points of support. With the horseshoe foot this is not the case, as the point of support is usually in such a position that at any considerable inclination the instrument is unstable, while in a horizontal position for photomicrography or projection, some Continental types are so unevenly balanced that they will not even stand alone, much less allow of the proper use of their various adjustments. This may be in part overcome by clamping the instrument down to some stable base for such special purposes, but no microscope with any pretension to be regarded as well designed should require that precaution.

The influence of this condition is now being felt very largely, and most Continental makers are either adopting a more stable method of support approximating to the English model, or are embodying the English type in their later makes of stands. In some cases a fusion of the two types appears to have been attempted, with certainly beneficial effects, but unfortunately the objections to the Continental model are still to be met with in some that have only in part realized the advantage of the English design. Continental microscopes have also long been open to the objection that their substage arrangements are altogether too cramped, and as it is only for very special purposes that a microscope is of necessity a portable instrument, the reason for this is not easily seen; certainly some more space underneath the stage, a greater range of action of the substage condenser, and considerably more freedom of movement of the mirror, would result in the production of a more convenient style of instrument.

It is extraordinary how widespread the applications of the microscope are at the present time. A recent article on its use in metallurgy and engineering, by Mr. W. Rosenhain, which appeared in these columns (vol. lxxx., p. 250), has sufficiently and clearly indicated its value in this direction. It is well enough known that in trades like brewing the microscope has played a very important part, and, in fact, it may be said that all trades which are concerned in the production or use of fluids for human consumption—at least where the work is carried out on anything approaching a large scale—are now compelled to have the service of a trained microscopist. Dairy workers, mineral-water makers, and all authorities concerned with the supply of pure water for drinking purposes are equally interested in the question.

As indicative of how great is the interest in this direction, it may be mentioned that the Cunard Steamship Company and the White Star Line have inquired of well-known makers for instruments and complete outfits suitable for their use. The presumption is that they intend to initiate some method of microscopically examining the water supply on their vessels, constituting, in fact, a miniature water board to insure that their water supply is as free from any bacterial or similar contamination as even that to be obtained in great centers of population.

As indications of some other directions in which microscopes are being utilized, it may be mentioned that chemists and druggists, paper manufacturers, makers of Portland and other cement, such as the Associated Portland Cement Company, foundrymen, printers and half-tone block makers for photographic reproduction purposes, quarrymen, linen, cotton, and silk manufacturers, and various other allied trades, are using microscopes at the present time. Petrological microscopes, in the development of the design of which great improvements have been made of late, are being applied now for testing stone and for supplying architects with exact information as to the structure and quality of the stone supplied by quarrymen, and as to the suitability of such material for building purposes.

As the result of a series of lectures given to laundrymen by Prof. Herbert Jackson, of King's College, an interesting further use of the microscope has recently arisen. Some large laundries and dyeing and cleaning establishments are now installing a microscopical outfit. The result of this may be fairly widespread, as it will now be possible, when a customer brings an article to be cleaned or otherwise dealt with, to determine its exact constitution before any effort is made to carry out the process. The result may be that an article which has been, for example, described originally to the purchaser as pure silk may at once be recognized by the laundryman as something totally different, and he may thus be saved from many unpleasant recriminations and possible legal claims by obtaining definite knowledge of the article before doing any work to it. One single thread detached from the article will usually supply all the information required, and will, in addition, often decide the best method or process that can most suitably be employed to effect the desired renovation.

There is still need, however, for much educational work in the use of the microscope, and it is much to be regretted that there appears to be no institution where systematic instruction in its various uses and possible application can be obtained. Even an elementary course in the use of the instrument, suited to the requirements of the student, would be more than useful. Medical students and others, who may sooner or later engage in research work, are too often given the barest instruction in microscopic technique, and it is easy to see that, could they but have even a short course of instruction—which should be regarded, not merely as incidental to, but as an absolutely necessary preliminary portion of their class work—then much of the rough-and-ready usage seen in the course of laboratory work might be avoided. It seems almost absurd that a student who is taking a course in bacteriology or pathology, which at its best requires the very highest knowledge of the use of the microscope, should usually receive little or only the barest and most superficial instruction in the methods of use of the instrument. With the great increase in the number of applications of the microscope, it may become essential that means should be provided for teaching systematically the elements of the theory of microscopic optics and the methods of using the instrument and its optical parts, and it is to be hoped that at no distant time this necessity will be recognized in some institutions of higher education.

* Nature.

The new photographic developer, "pyramidol," a German product, is one of the most powerful obtained, and it can even develop a plate in a pure water solution, although this is not done in practice. It is a sulphate of a combination of paramidophenol and hydrochinon. Its action, according to L. P. Clerc, is to be compared to mixtures of metol and hydrochinon, but without the danger to the skin which metol sometimes occasions upon long use.

SAFETY DEVICES FOR STEAM BOILERS.

A DESCRIPTION OF NOVEL WARMING APPARATUS.

THE carelessness with which steam boilers are watched is shown by the fact that in the German Empire in the years 1900 to 1907 one hundred and twelve explosions occurred, in which one hundred and thirty-seven persons were killed or injured. Not all of these explosions were due to lack of attention, some of them being caused by local defects, poor material and other constructive deficiencies. Sixty-five of the explosions, however, were due to too low a water level or carelessness on the part of the operator, and eleven cases were caused by excessive steam pressure. These figures speak for themselves and show that the most carefully devised official regulations and safety appliances are insufficient to prevent explosions, often of very serious character. Inventors constantly endeavor to devise, in addition to the appliances prescribed by law, safety devices and warning signals intended to act early enough to enable the threatened danger to be averted. These appliances are especially devised to prevent explosions due to too low a water level or too high pressure of steam.

The Schwartzkopff firm, of Berlin, has put on the market a warning signal, the construction and operation of which may be described as follows: The apparatus (Fig. 1) consists of two concentric tubes, *a* and *i*, which are connected rigidly together by flanges and are attached to the top of the boiler. The outer tube *a* is closed at the top, and its lower and open end extends inside the boiler to the lowest allowable water level. The inner and much longer tube, *i*, is open at the top, which is considerably higher than the top of the outer tube. The lower and closed end of the inner tube is a little below the low water level. The tubes communicate through a serpentine tube *o*, which winds round the top of the inner tube. The inner tube contains two stout, copper wires, *d* and *d'* (Fig. 2), which are insulated from each other by diaphragms of slate *m m*$_1$ *v v*$_1$, through which they pass. The wires are connected by binding-posts to an electric bell circuit.

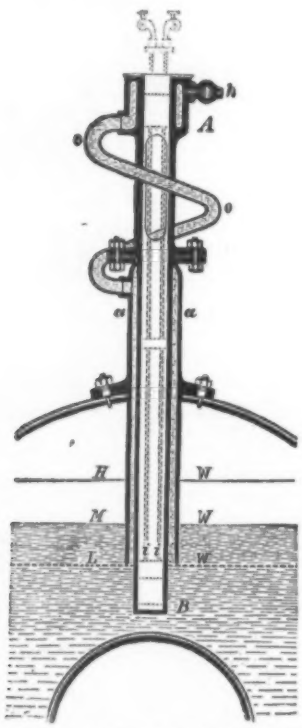


FIG. 1.—A NEW SAFETY DEVICE FOR STEAM BOILERS.

If the water in the boiler stands at the normal level, *M W*, it will stand at the same height in the annular space between the tubes before the boiler is heated, but the slightest pressure of steam will cause water to rise through the outer tube and the serpentine tube to the top of the apparatus as soon as the air-cock *h* is opened. The tubes being small, the water contained in them is soon cooled by radiation and remains at a temperature below 212 deg. F. so long as the mouth of the outer tube remains sealed by the water in the boiler, but when the water level sinks, and the mouth of the outer tube *a* is left open, the water collected in the tubes of the apparatus falls back into the boiler and is replaced by steam at the temperature and pressure then reigning in the boiler. This hot steam, penetrating into the head of the apparatus, *A*, melts a ring of fusible metal *l* (Fig. 3). The melted metal runs down into the cavity *k*, makes a metallic contact between the wires, and thus sets into action an alarm bell in the boiler house, office or elsewhere. The signal is given so soon that sufficient time is left to take energetic measures to avert the danger of explosion.

As the apparatus is water-tight and steam-tight, it is easy to draw out the wires, remove the melted metal and insert a new fusible ring. When the normal water level in the boiler has been restored, the air-cock *h* is again opened, the water rises as before, and the apparatus is ready to give a new signal when needed.

FIG. 2.—ELECTRIC WIRES.

In the lower part of the apparatus (Fig. 4) is a second fusible ring, the melting-point of which is at a temperature corresponding to a steam pressure about one atmosphere higher than the highest allowable boiler pressure. This ring, which is situated near the top of the fire-box, melts and establishes contact between the two wires as soon as the top of the fire-box acquires a temperature of from 480 to 660 deg. F. This occurs, for example, when the boiler is heated without having been filled. This apparatus also operates very promptly, before the boiler plates have become red hot and have thus been weakened. The correctness of the temperature of fusion of the rings is assured by having them tested and stamped by the Physikalisch-technische Reichsanstalt.

In order to be able to make sure of the readiness of the warning apparatus at any time, there is placed in the boiler house or elsewhere a push button, from which two wires lead to the wires of the apparatus. If this button is pressed, the wires are put into metallic communication, as they are by the fusion of the ring. If the bell rings, the official in charge has the assurance that the apparatus will perform its function when either of the rings is melted. In an establishment containing many boilers, the system of warning signals may be so arranged that a glance at an annunciator will show which boiler is in danger of explosion.

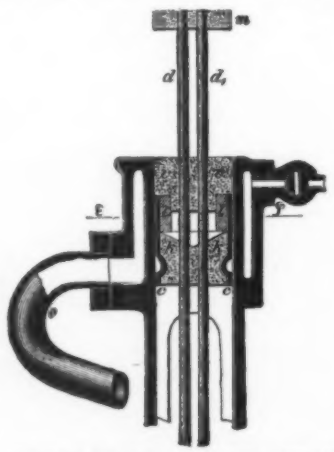


FIG. 3.—UPPER PART OF THE APPARATUS.

Another warning signal, made by the same firm, consists of a blow-off cock (Fig. 5) placed below the mean water level with its channel connected with a vertical tube, which is provided with radiating plates *k*, and is expanded at the top into a head. In this head is screwed from above a short tube *r*, the lower end of which is closed by a fusible plug pressed firmly against the orifice by a screw. So long as the water in the boiler stands at the normal level, the outer tube remains filled with water, except at the upper part of the head, which contains the air which was in the apparatus in the beginning or has been expelled from the water in boiling. In consequence of radiation, the temperature of this water is so low that the fusing point of the plug, which ranges from 212 deg. F. to 257 deg. F according to the normal boiler pressure, is not attained. If, however, the water in the boiler falls too low, the water in the tube falls back into the boiler, and hot steam enters the tube and almost instantly melts the plug. The orifice now being left open, the steam escapes into the atmosphere with a loud hissing sound which warns the attendant of the dangerous condition of the boiler. This warning is independent of that given by the water gage, the indications of which may be made erroneous by muddiness or great hardness of the water. The sound may be increased in loudness by the addition of an ordinary steam whistle (Fig. 6). The apparatus is again made ready for use by closing the cock *h*, unscrewing the tube *r* and inserting a new fusible plug. After the water in the boiler has again attained the normal height, the cock *h* is opened and the apparatus is ready to give a new signal.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

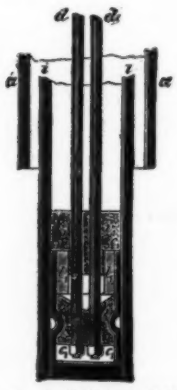


FIG. 4.—LOWER PART OF APPARATUS.

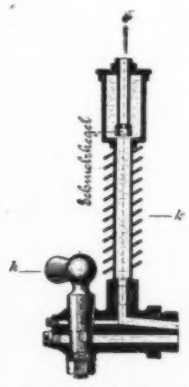


FIG. 5.—SAFETY COCK.

A recent hailstorm, the direction of which coincided with a high-tension electric overhead transmission system, has given rise to the suggestion that these lines possibly play an important part in meteorology. Experiments have been carried out to test this point, using the electroscope and cylindrical condenser method perfected by Chéneveau and Laborde. The experiments were carried out in the neighborhood of a three-phase 50,000-volt line. Samples of air close to the wires gave 0.05×10^5 ions per cubic centimeter. Near the lightning arresters, etc., where there was a strong odor of ozone, the number was between 0.04 and 0.05×10^5 ions per cubic centimeter. At a neighboring town the number varied between 0.07 and 0.09.

FIG. 6.—SAFETY COCK WITH STEAM WHISTLE.

From these experiments it is concluded that very close to the wires there are sensibly no ions. It is ordinarily stated that the wires are continually giving out ions. But in all cases it was found that the number is less near the wires than in the neighboring country.

AERODYNAMIC AND AEROSTATIC STUDIES.

EXPERIMENTS WITH MODELS OF AIRSHIPS AND AEROPLANES.

BY PROF. L. PRANDTL.

IT is now almost the universal practice of shipbuilders to test new forms of hulls by towing models, usually made of paraffin and a few yards in length, through the water and measuring the resistance opposed to their motion. No large ocean steamer is now constructed without such preliminary experiments. Experiments with models of airships are still more necessary, because in the air we have not the practical experience that we have in the water. In both cases one of the chief objects of study is the total resistance to motion and the discovery of the form which will make this resistance a minimum. Other important questions concern the distribution of pressure and skin friction in their dependence upon the form and character of the surface. The investigation of stability and steering qualities also requires experiments with model which may likewise give interesting information of the lifting power, or kite action, of the airship when inclined to the horizontal. In the case of aeroplanes it is necessary to study thoroughly the magnitude and direction of the resultant force on single surfaces of various forms, on combinations of surfaces, and finally on complete aeroplanes, and the stability and steering qualities must be determined as in the case of the airship. The question of power and

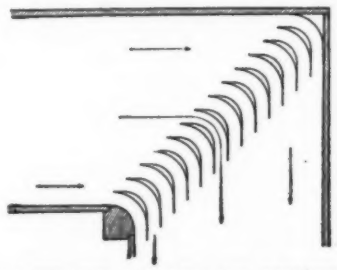


FIG. 1.—CURVED GUIDES AT CORNERS OF AIR CHANNEL.

propelling mechanism is the same for both classes of vessels, and may also be studied by means of models. It is more convenient, simpler, and cheaper to learn from models all that they can teach us, than to make the experiments with large and expensive vessels. The question, however, suggests itself, how far the results obtained from models can be applied to the large vessels. It must be admitted that here, as in the case of nautical vessels, this applicability is not perfect, on account of the peculiarities of the so-called skin friction. If the skin friction is neglected, the results obtained from the model can be applied to the large vessel if the following simple rule is observed:

Forces are proportional to areas and to the squares of velocities.

Experiments with models can be conducted accord-

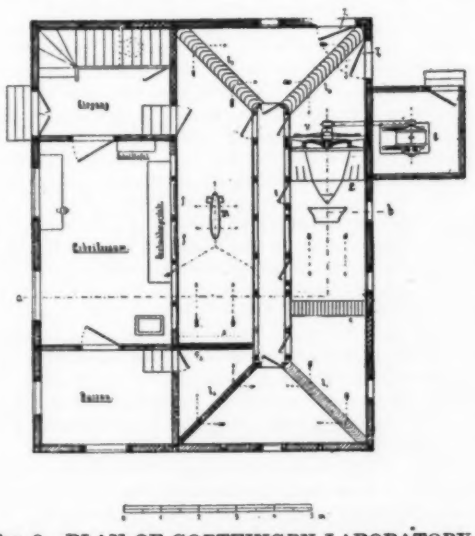


FIG. 2.—PLAN OF GOETTINGEN LABORATORY.

ing to several very different systems. The first system corresponds to that employed for nautical vessels, in which the model is towed by a carriage running on rails. This method is not suitable for aerial vessels because, as everything is surrounded by the same medium, the carriage would generally create a greater disturbance in the air than the model would produce —a disturbance sufficiently great to make exact measurement impossible. By replacing the towing carriage with a cord wound on a windlass this objection is removed, but it remains very difficult to distinguish sharply the comparatively small air resistances from the great forces of inertia of the heavy model. For

FIG. 3.—MOUTH OF FINE EQUALIZER.

the sake of completeness we may also mention experiments of the free fall of a body through the air, from which very good results can be obtained by a skilled experimenter. The frequently employed method of carrying the model round in a circle by means of a long rotating arm is open to the objection that the model is always moving in air which has been disturbed by its last passage.

In great contrast to all these methods, in which the model moves in approximately still air, is the method of maintaining the model at rest in a current of air produced, for example, by a ventilating fan. The mutual action between the model and the air is here exactly the same as in the former system, if the condition of the moving air before it strikes the model is as uniform as that of still air. The trustworthiness of results obtained by this method depends, therefore,

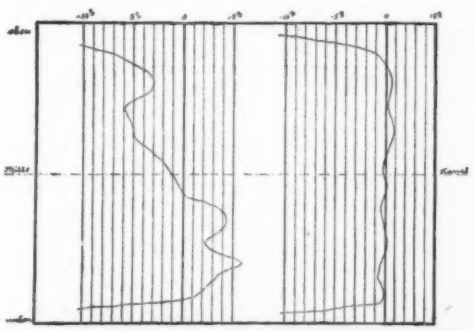


FIG 4.—CURVES OF DISTRIBUTION OF PRESSURE IN FRONT OF (LEFT CURVE) AND BEHIND (RIGHT CURVE) THE EQUALIZERS.

upon obtaining a uniform current, free from eddies. This can be secured by the employment of various appliances. When a uniform current has been secured, the advantages of this method are great and obvious. The duration of the experiment is unlimited, and the model can be attached to its support much more easily and securely than if it were in motion. Furthermore, the difficulties produced by the acceleration and inertia of the model and the measuring apparatus are here avoided, and the model is continuously in sight, so that any irregularities can be at once detected and corrected.

Two systems of construction, the open and the closed, are possible. In the open system the air is drawn from the atmosphere through the experimental channel and expelled at the farther end. In the closed system a confined body of air is kept moving in an annular closed channel. The unavoidable formation of eddies forms an obvious objection to the closed system, but careful comparison proves that it is, on the whole, far superior to the open system, which is exposed to serious disturbances caused by wind. The necessity of reducing again to uniformity the current of air disturbed by the ventilating fan, and the loss of energy in this operation, are small disadvantages in comparison with the advantage of being independent of the weather.

The Goettingen experimental institute has been designed in accordance with this system. As a member of the technical committee of the Aeronautical Society, the writer, in January, 1907, designed an experimental laboratory which was completed in the summer of 1908. The internal equipment is now nearly finished. The air channel is square in section, measuring 6½ feet each way. This form was adopted for convenience in construction and inspection. The current of air is produced by a screw propeller, which was adopted on account of simplicity and cheapness, although a centrifugal blower produces a more uniform current and consumes less power. For the sake of simplicity, also, the canal follows the sides of a rectangle, but the air is guided round each corner in a number of small streams by means of curved fixed surfaces, as shown in Fig. 1. The apparatus by which the air disturbed by the fan is quieted and made uniform consists of a large system of guiding surfaces immediately behind the fan, which distribute the current over the whole cross section of the canal, and of a coarse and a fine equalizer, of which the former contains 400, and the latter about 100,000 parallel channels. Finally, the air passes through a sieve of 1/12-inch mesh. Fig. 2 shows the ground plan of the laboratory.

The fan *V* is driven by a 30-horse-power electric

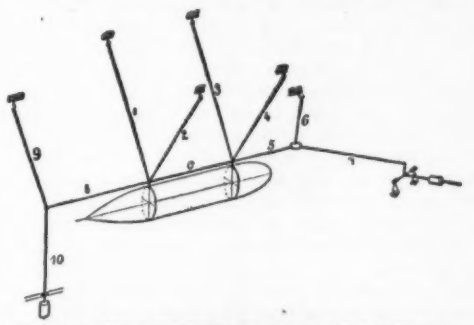


FIG. 5.—ARRANGEMENT FOR MEASURING LONGITUDINAL RESISTANCE.

motor *E*. Near the fan is the distributer *L*. The coarse equalizer G_1 is a little distance farther on, while the fine equalizer G_2 is on the opposite side of the rectangle. The curved blades at the upper corners of the figures are 20 in number. Those at the other corners, between the two equalizers, number 40 and 80, respectively.

Fig. 4 illustrates the distribution of velocities before and after passing through the distributer and equalizers. The model *M* is suspended in the branch of the channel opposite the fan and can be observed conveniently through the glass windows which separate the channel from the observation room on the left, where all the measuring and regulating mechanism is installed. The speed of the fan can be modified within the ratio 1 to 4. Hence the velocity of the air current can be varied in the same proportion and, as the air pressure is proportional to the square of the velocity, the pressure can be varied in the ratio 1 to 16, which is a sufficiently wide range for practical purposes. The

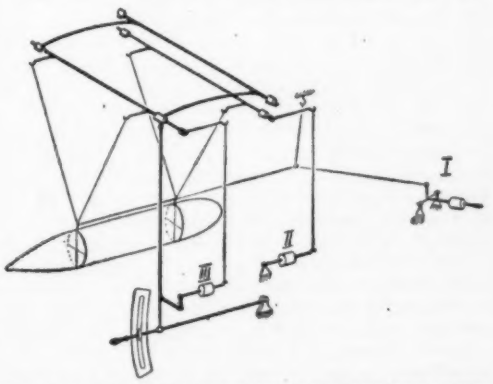


FIG. 6.—ARRANGEMENT WHICH ALLOWS THE AXIS OF THE MODEL TO BE INCLINED TO THE CURRENT.

velocity of the current is measured by means of a modified Pitot tube, in conjunction with a micromanometer. (The Pitot tube, as used for the measurement of the velocity of water currents, is an L-shaped tube, the short leg of which is immersed and directed against the current. The strength of the current is measured by the height to which the water rises in the vertical branch.) One of these instruments is

placed in front of, and another behind the model. Each is so arranged that it can be moved to any point of the cross section of the channel. The manometers are provided with registering apparatus. In order to avoid interference with the current, the suspension of the model and the transmission of power are effected as far as possible by the use of wires. For the measurement of the simple longitudinal resistance the arrangement shown in Fig. 5 has been adopted. The model is attached to a thin rod *O*, suspended by the four wires 1, 2, 3, 4. The longitudinal force exerted along wire 5 is transmitted with undiminished strength to the wires 6 and 7, each of which makes an angle of 120 degrees with wire 5. This force is measured by the balance attached to the end of wire 7. Wires 8, 9, and 10, the last of which is loaded with a weight, form a tension system which serves to maintain the position of the model when not exposed to the air current. In making a measurement the balances are first adjusted to equilibrium when the air is at rest. The ventilator is then started, the balances again adjusted, and the weights recorded. The difference of the weights gives the force exerted by the current upon the model and the suspension system combined.

The force exerted upon the suspension system can be measured separately by repeating the experiment after removal of the model. The velocity of the air current is meanwhile recorded by the self-registering apparatus described above. This measurement is taken at a place in the channel behind the model and beyond the influence of its wake. The problem of determining the magnitude and direction of the resultant effect of an air current which has any given direction in the vertical longitudinal plane is solved by adding to the foregoing measurements the tensions produced in wires 1, 2, 3, and 4. The force which tends to turn the vessel can be measured by an additional wire and balance. For example, in Fig. 6 the horizontal longitudinal component is measured by balance *I*, the vertical component by the mean of the readings of *II* and *III*, and the deflecting force by a fourth balance (not shown). In order to measure with the utmost generality the six components of the forces acting upon an unsymmetrical body, the body, after the first measurement, must be turned through a right angle and the measurement repeated. As it is often necessary to investigate the dependence of the force upon the angle between the axis of the object and the direction of the current, the apparatus is so arranged that the balance *III* can be raised and lowered, by which means the model is turned round a horizontal transverse axis.

An extensive programme of work has been arranged for the laboratory and new problems will continually arise for solution.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

THE PARIS AVIATION EXHIBITION.—II.*

PARTICULARS OF SOME OF THE AERONAUTIC MOTORS SHOWN.

Continued from Supplement No. 1765, page 283.

In addition to the aeroplanes shown there are numerous engines specially designed for use in them, and in the structural points of these there is very much more diversity than in the aeroplanes themselves. The number of cylinders varies from two to sixteen, and these are arranged in every conceivable manner. The essential object is, of course, to reduce the weight as far as possible, consistent with reliability over the time which a flight is likely to occupy—a period which has, so far, not much exceeded three hours. Durability, in the ordinary sense of the word, is not necessary. Weight is, of course, of the greatest importance in every motor which moves itself, such as a motor-car engine or a marine motor. Hence such apparatus are made as light as possible consistent with due reliability, durability, and accessibility; and in the racing motor-car and launch-engines the weight has been made as small as is consistent with their maintaining their power with certainty over the period of a race, which is never more than a few hours.

In producing a motor still lighter than these there are several courses open. The simplest is to take an engine of fairly ordinary and substantial construction, and to increase the power developed by cylinders of a given size. This can be done by raising the compression and increasing the rate of revolutions, the valves being made of suitable size. That is to say, we have a substantially-built engine, which is run very hard. The second plan is to retain the ordinary vertical type of engine, but to reduce the weight for a given cylinder capacity by the use of thin steel cylinders, and very light construction of all the parts. The third plan is to reduce the weight of the crank-case and other parts by putting more than one connecting-rod to each crank. The simplest form of this is the diagonal type, in which two cylinders work on to each crank. The most usual form is the eight-cylinder diagonal with four cranks, though several examples are shown of four-cylinder engines with two cranks. The extreme form is that in which several cylinders are grouped round a crank-case of the length usual for one cylinder, all working on to one crank.

A further way of reducing the weight is to do away with the water-cooling, and substitute air-cooling. In this case the whole of the weight of the radiators and the contained water is saved, but, on the other hand, it is doubtful whether it will be possible to maintain the same horse-power for a given cylinder capacity. The question of air-cooling *vs.* water-cooling may depend on many factors, and we shall refer to this matter later. Meanwhile it may be remarked that, although the cross-Channel flight, and the record for distance have been performed with air-cooled motors, the water-cooled engines are in a very large majority at the exhibition.

The table annexed gives the particulars of several engines exhibited, and will give a fair idea of the lines on which the various constructors are working.

It will be seen that much the lightest engine per horse-power is the "Gnome." This engine was fitted to the Farman aeroplane which holds the record for the longest flight, and was illustrated in SCIENTIFIC AMERICAN SUPPLEMENT No. 1729. It is of the extreme radial type, as the whole of the cylinders are grouped round one crank-case, and attached to one crank, the crank in this case being fixed and the crank-case and cylinders revolving. The success of the engine does not, however, depend entirely on the general outlines of the design, but is largely due to the extreme care taken in the construction, the cylinders and crank-case, every part, in fact, being machined out of high-grade steel. The rotary cylinders lend themselves admirably to air-cooling, as their rapid motion through the air helps to cool them, and the engine is in every way apparently well adapted to experimental purposes; but it may be doubted whether it will be so well suited to practical work when the aeroplane gets out of the experimental stage. The inlet-valves are automatic, and placed in the pistons, and therefore very inaccessible, while the centrifugal force of the exhaust-valves has to be balanced by a system of rocking levers. There are also difficulties in distributing the necessary current to the sparking-plugs without undue complication, and at present there is no attempt at any silencer. Even with the very complete cooling the cylinders get it will be seen from the table annexed that the power claimed is very low in proportion to the size of the cylinders.

TABLE GIVING CHIEF PARTICULARS OF AEROPLANE ENGINES.

—	Type.	Horse-Power.	Air or Water Cooled.	Cylinders.			Cylinder Capacity.	Weight.	Cylinder Capacity per Horse-Power.	Weight per Horse-Power.	Weight per Cubic Inch of Cylinder Capacity.
				Diameter	Stroke.	No.					
				mm.	mm.		cub. in.	lb	cub. in.	lb.	lb.
Gnome	Rotary	50	Air	110	120	7	487	168	9.7	3.4	0.35
"	"	100	"	110	120	14	974	220	9.7	2.2	0.23
Anzani	3-cylinder	30	"	105	130	3	297	143	6.9	4.8	0.49
"	"	40	"	120	140	3	390	187	7.2	4.7	0.65
"	"	50	"	125	150	3	391	222	7.8	4.6	0.59
"	4-cylinder double diagonal	35	Water	100	120	4	230	182	6.6	5.2	0.79
"	4-cylinder double diagonal	70	"	135	150	4	522	296	7.4	4.2	0.57
Darracq	Opposed	30	"	130	120	2	194	121	6.5	4	0.62
"	"	60	"	130	120	4	388	242	6.5	4	0.62
Panhard	4-cylinder vertical	40	"	110	140	4	323	198	8.1	4.9	0.61
Bayard	" "	40	"	100	120	4	230	242	5.8	6.1	1.05
Aster	" "	50	"	130	140	4	455	242	9.1	4.8	0 53
Renault	" "	50	"	110	160	4	370	286	7.4	5.7	0.74
"	Diagonal	50	Air	90	120	8	672	374	7.4	7.5	1.05
Mors	"	45	Water	110	130	4	301	203	6.7	4.5	0.68

Among the other engines, of which particulars are given in the table, there is not a very great difference in the weight per horse-power, this ranging from 4 pounds per horse-power to 7.5 pounds, the lightest being the Darracq, water-cooled, and the heaviest the Renault, air-cooled. It may, however, be observed that, with the exception of the Renault, the weights of the water-cooled engines do not, as a rule, include the radiator and water, and this will add from 10 per cent to 20 per cent to their weights in most cases. On the other hand, it is not clear how long the air-cooled engines will maintain their power. It is usual for makers of air- and water-cooled engines to claim the same power for equal-sized engines, whether air- or water-cooled, while in practice the power of the air-cooled falls very rapidly in use as the cylinder gets hot. The Renault air-cooled engine is provided with a fan for cooling the cylinders, and it is understood that its maintained power has been officially tested, but in this case the weight per horse-power is greater than that of the water-cooled engine with radiator, by the same makers. Both of these engines were illustrated in SUPPLEMENT No. 1728.

One of the most interesting engines at the show is undoubtedly the two-cylinder Darracq. This engine is of extremely simple construction, as it has only two cylinders, and these are placed horizontally at opposite sides of the crank-case. The diameter of the cylinders is 130 millimeters (5⅛ inches), the stroke 120 millimeters (4¾ inches), and the power is stated to be 25 to 30 horse-power. Both inlet and exhaust valves are placed in the cylinder-head, and are driven by means of rocking-levers. There is an inclined camshaft, which drives the magneto at one end and the water-pump at the other. No exhaust-pipe is provided, and there is a row of holes in the cylinder, which the piston uncovers at the bottom of the stroke to provide a freer exhaust. There is no fly-wheel, the engine being coupled direct to the propeller. An engine of almost identical construction is used by Santos Dumont. As his is the lightest and fastest aeroplane in existence, it appears that if the engine is light enough for it, it should be light enough for most things, and the advantage of very numerous cylinders for reducing weight is very doubtful in practice. Messrs. Darracq also show a vertical engine with separate cylinders, 170 by 140 millimeters (6¾ inches by 5½ inches), having the valves in the cylinder-heads, and giving 100 to 120 horse-power. This engine was illustrated in our last issue.

Next simplest to the two-cylinder engine is naturally the three-cylinder. Of this the Anzani, the type used by M. Bleriot in his flight across the Channel, is naturally the most interesting example. This can be seen in the picture of the Bleriot monoplane. In this case the three cylinders are placed radially around the crank-case at angles of 60 deg. The engine is directly coupled to the propeller, and the draft from this blows on the cylinders, the arrangement of which allows of its striking directly on all of them, while the heads are so far apart as to have no tendency to heat each other. The valves are arranged with the inlet over the exhaust, the former being automatic, and there are holes in the cylinder walls which the pistons overrun to secure a free exhaust.

An air-cooled engine of a totally different type is exhibited by Messrs. Renault Frères. This engine (which, as well as the water-cooled one of the same maker, was illustrated in SUPPLEMENT No. 1728) has eight cylinders disposed diagonally on a four-throw crankshaft. Naturally, with cylinders so arranged the draft caused by the aeroplane going through the air would not be enough to keep them cool, as the cylinders would screen each other. Further, the cylinders are so close together that their heads will radiate a considerable amount of heat to each other. Accordingly a powerful fan is provided, running at the engine speed, which blows a strong draft of air past the cylinders. The latter are 90 by 120 millimeters (3½ by 4¾ inches), and have the valves placed over each other, the inlet-valves being driven by rocking-levers. A feature of this engine is that the cam-shaft is driven by gearing capable of transmitting the whole power of the engine, and is prolonged so that the propeller can be mounted on it if desired, and therefore run at half the engine speed. Messrs. Renault also exhibit a

* Engineering.

vertical four-cylinder engine, with the valves in the cylinder-heads driven by rocking-levers. The cylinders in this case are 110 by 160 millimeters (4⅜ by 6½ inches). These two engines are both stated to give 50 horse-power. Several other engines of various sizes are also exhibited.

Messrs. Panhard and Levassor show several engines of various sizes, all having separate cylinders with copper water-jackets, the most interesting of which is a new pattern specially designed for aeroplanes. In this engine the inlet and exhaust are both placed in the cylinder head concentric to the cylinder, the inlet being inside the exhaust. Both valves are worked by one tappet-rod from the cam-shaft by means of a system of rocking-levers so arranged that when the rod is raised by the cam it opens the exhaust-valve, and when it is depressed it opens the inlet. The cylinders are 110 by 140 millimeters (4⅜ by 5½ inches), and the engine gives 40 horse-power, the weight being about 200 pounds. It is therefore an example of an engine with large cylinders for its power, but of very light construction for its cylinder capacity.

A point which may possibly require more attention than it has hitherto received is the question of running an engine with no flywheel except the propeller. In such a case the propeller blades near the root may be subject to a considerable stress alternating with every revolution of the engine, the amount of this depending on how many cylinders the engine has. Such stresses tend to weaken the material, and therefore, if durability is required, it may be necessary to make the propeller-blades considerably stronger with two- and three-cylinder engines having no flywheel than with engines with a more even turning moment. Wooden propellers seem more in favor than those of metal, and probably are more suitable, as wood is well able to stand the above stresses, and it is easy to make the propeller strong at the root without excessive weight. The wreck of the dirigible "République," and death of the four men composing her crew, from a broken propeller shows that danger from this cause is not imaginary, and the results in an aeroplane would probably be at least equally disastrous.

(To be continued.)

SMOKELESS COMBUSTION.

THE CONSERVATION OF COAL.

THE problem of smoke abatement is one that is constantly before engineers in charge of generating plant, and has received a large amount of attention within recent years. An interesting paper by Mr. C. L. Hubbard, on "Smokeless Combustion," appears in the Electrical Review and Western Electrician. It is probably true, says Mr. Hubbard, that comparatively few stokers are familiar with the nature of the chemical actions which take place in the boiler furnace during the process of combustion. While such knowledge is not absolutely necessary in order to avoid the formation of smoke, an understanding of the elements of any process is always the first step in successfully carrying on the same, whether it be the manufacture of some article, the running of a machine, or the burning of coal under a boiler.

A careful investigation of the matter of smoke consumption as reported by various experts lays particular stress upon firing and furnace construction, and these are taken up briefly along the lines especially affecting the formation or prevention of smoke.

First, the process of combustion is considered without reference to where it takes place or to the nature of the fuel. Chemically speaking, combustion is the combination of oxygen with certain elements which produce heat and light. The substance with which it combines is called the combustible, or when combustion takes place in an ordinary furnace it is called fuel. The chief elements of a fuel are carbon and hydrogen, and the products of perfect combustion are water, which consists of two atoms of hydrogen and one of oxygen (H_2O), and carbon dioxide or carbonic acid, as it is usually called, which is a gas made up of one atom of carbon and two of oxygen (CO_2). In the process of combustion as it takes place in a furnace, the oxygen is taken from the air which enters through the draft doors, and this unites with the carbon and hydrogen in the fuel, forming carbon dioxide and water.

In order to secure perfect combustion, oxygen must be present in just the right proportion to unite with the elements of the fuel, as stated above. If there is not a sufficient air supply, carbon monoxide (CO) will be formed instead of CO_2, and this greatly reduces the quantity of heat produced. For example, if a pound of carbon is converted into CO, it will generate 4,400 heat units, but if double the amount of air is supplied, CO_2 will be formed and 14,600 heat units will be given off, provided the temperature is maintained at the proper point. On the other hand, if too much air is supplied, it lowers the temperature below the point necessary for complete combustion, and so the results may be no better than when the air supply is too small. When combustion is not complete, some of the hydrogen, together with the carbon with which it is usually combined (called hydrocarbon), may be distilled from the coal and not burned, or the hydrogen only in this volatile matter may be burned, leaving the carbon in the form of soot or smoke, to be carried off in the gases passing out of the furnace. Smoke is a sure evidence of improper combustion, but it does not follow that where there is no smoke combustion is perfect. The perfect combustion of coal in a furnace can only be effected by a sufficient supply of oxygen supplied under proper conditions. The most important of these are a high temperature and an intimate mixture of the air with the fuel.

Coal is a compound substance and may be decomposed by heat into several distinct constituents, but in combustion we deal principally with but two—carbon in the form of coke, and hydrogen, generally known as gas. These two elements practically contain the full heating properties of the coal. We say that when coal is thrown upon a fire it commences to burn, but before any burning takes place it is decomposed into its constituent elements. The gas, having been distilled by the heat of the fire, burns first by its chemical union with the oxygen of the air, forming water. The gas having been disposed of, the coke burns in a similar manner, forming carbonic acid.

In order to ignite a substance and keep it burning it must be heated to a certain kindling point and kept up to that temperature. While the gas is being expelled from the coal the latter remains at a relatively low temperature; no particle of solid coal can burn while gas is issuing from it. A lump of coal may, however, be giving out gas in one place while it has been expelled from another and the remaining coke has already ignited. Coke does not produce smoke in burning; this is only formed during the distillation of the gas. To support combustion it is necessary to maintain a temperature of at least 800 deg. F. At temperatures lower than this there can be no burning of the coal. It is common in furnaces to have a temperature of 3,000 deg. F. and over, just above the bed of live coals on the grate. The amount of air required by a pound of soft coal to completely burn it is approximately 12 pounds, or 150 cubic feet. The actual amount needed in practice depends upon the force of the draft and upon how thoroughly the air and the gases are mixed. Former practice with ordinary chimneys allowed 24 pounds of air per pound of coal. With improved draft and better grates this has been reduced to 18 pounds, and where combustion tubes or steam jets are used above the fire 14 pounds has sometimes been found sufficient. The disadvantage of using too much air is the cooling of the fire, which retards combustion and reduces the transmission of heat, and second, the reducing of the chimney draft by cooling the stack. Every extra pound of air has to be heated by the fire, and this heat passes up the chimney without being used. The quantity of air, however, should vary with the condition of the fire. Just after firing, when the gases are being distilled rapidly from the coal, more air must be admitted; after the coal becomes incandescent a comparatively small supply is needed.

The object to be attained in smokeless combustion is to prevent the formation of smoke rather than to provide means for burning it after it has been allowed to form. The action of combustion and the effect upon it of different conditions is well illustrated by a paraffin lamp, and although this example has often been made use of, it may well be repeated in the present case. If we take a lighted central draft lamp and adjust the wick to such a point that it gives a rather short and clear white flame without a trace of smoke, then gradually obstruct the opening at the bottom, the following result will be observed: First, the flame will grow longer and its color change from white to yellow, and then to red, and it will also begin to smoke. Finally, when the air supply is nearly shut off the flame will rise almost to the top of the chimney, at the same time giving off a column of dense black smoke and soot. In this example the wick represents the automatic stoker, supplying fuel automatically; the perforated gauze at the base of the burner is the grate which heats and regulates the air supply, while the chimney regulates the force of the draft. The smoky flame caused by turning up the wick is analogous to that caused by adding too much coal at one time to a furnace. If the supplies of air and fuel are properly adjusted to each other the flame will burn clearly and steadily without a trace of smoke. If on the other hand the wick remains the same and the chimney is raised from the base, smoke will again appear, because cool air rushing in above the gauze checks combustion by cooling the flame. If a cold metal rod or strap be passed down the chimney into the flame it will become coated with soot, due to the chilling effect upon the burning gases. In like manner, too close proximity of a crown sheet to the fire causes soot in a boiler furnace.—The Steamship.

FUEL FROM PEAT.

IT has been estimated that there is more carbon contained in the peat deposits of the world than in all known coal fields, in spite of the fact that mature peat contains 7 tons of water for each ton of dry peat substance. It is technically impossible to separate the larger portion of this water from mature peat by mechanical pressure, because of the presence of a slimy hydrocellulose produced by the residues of the decaying plants of which mature peat consists. Under the microscope, using suitable stains, this hydrocellulose can be seen as a jelly. The hydrocellulose is destroyed by heating, and this forms the special feature of the author's process for dealing with peat. The heating medium used is superheated liquid water, and the method of treatment is therefore called "wet carbonizing." The effects of "wet" as compared with "dry" carbonization are set forth in a number of tables, and a diagram is given showing the relation between the pressure used and the pounds of water expelled at different temperatures of carbonization. Discussing the practical applications of the new process, M. Ekenberg states in Iron and Steel Inst. Jour. the experimental results prove that by previously heating the peat to a certain temperature (180 to 220 deg. C.) the bulk of the water can be mechanically expelled at a low pressure. The carbonization of the peat is instantaneous, and the time required for making fuel from the raw peat is only that required for heating, cooling, and pressing. The pressing can be effected within 1 minute, and the heating and cooling of the peat pulp ought not to require more time than the heating and cooling of an equivalent volume of water. The important question is, however: how much heat and power respectively will the process require? By use of the regenerative principle—the heat of the carbonized peat being given up to the incoming raw peat—from 57 to 65 per cent of the heat required can be obtained from the carbonized peat, and 100 kilogrammes-calories per kilogramme of wet pulp suffice to balance the process. About 14.3 per cent of the peat in the pulp has to be sacrificed in order to obtain this heat. Any press capable of working at 50 atmospheres can be used for pressing out the water. The cost of pressing is equivalent to a consumption of 1½ per cent of the peat, and the water-free wet-carbonized peat has a heating value of 11,000 British thermal units per pound. The cost of producing briquettes from peat, covering all the expenses of the wet carbonizing and briquetting process has been estimated by C. Dellwik at 6s. 8d. per ton, or 8s. 9d. per ton if hand labor be employed for excavation. The wet-carbonized peat may also be used for gas production in the Mond or Crossley type of gas-producer. A complete factory, consisting of wet-carbonizing plant, briquetting plant, and gas-production plant, with ammonia recovery, will shortly be at work in the United Kingdom and also in Germany.

There are in the United States over 250 makers of automobiles, and this number does not include makers of commercial motor vehicles and trucks. In short, it refers to makers of cars primarily for pleasure purposes. Upward of 100,000 workpeople are directly engaged in these factories, and not less than 4,000 allied industries and works are more or less dependent upon the motor-car industry. Truly this is remarkable growth, and if, by reason of its years, this is still an "infant industry," all must admit that it looks like a thriving infant.

THE LOETSCHBERG TUNNEL THROUGH THE BERNESE ALPS.

By Dr. Alfred Gradenwitz.

Soon after the completion of the Simplon tunnel, the construction of a tunnel through the Bernese Alps was begun, to establish a communication between Western Switzerland and France on the one hand, and Italy on the other. Through this new tunnel will pass a railway leading from Frutigen to Brigue at the northern end of the Simplon. This line is 33 miles in length, and comprises a considerable amount of tunneling in addition to the main tunnel 8½ miles in length.

After leading Frutigen, situated at an altitude of 2,560 feet above the sea level, the line continues along the eastern side of the Kander Valley. It then climbs up the valley side by means of a double bend and spiral tunnel, and at about the thirteenth mile reaches the entrance to the Loetschberg tunnel. The northern section comprises several short tunnels and a large number of bridges. The gradient averages about 1 in 37. The entrance to the main tunnel is situated at 3,935 feet above the sea level. The highest point of the line lies within the tunnel at a little more than 3.72 miles from the northern entrance, where the elevation of 4,594 feet is reached. The gradient in that portion of the tunnel is 1 in 443, and after passing the summit changes to a falling one of 1 in 263.

The northern entrance to the tunnel is at Goppenstein, at 4,000 feet above the sea level. The line then descends the Loetschen Valley, and just before reaching Giesch, bends, at right angles, toward the east, in order then to wind up the northern side of the Rhône Valley. It eventually crosses the river and joins the Rhône Valley line of the federal railways leading from Lausanne to the Simplon tunnel at Brigue. From Goppenstein to Brigue there are thirty-seven tunnels and twelve large bridges.

The construction work is controlled from the central office, located at Berne. The line was divided into four construction divisions, viz.:

(1) The northern approach.
(2) The actual tunnel work of the northern side.
(3) The actual tunnel work of the south side.
(4) The southern approach of the tunnel.

Each of these divisions has a separate installation of stores and tools.

All the machines and tools installed at Frutigen, which is the head station of the northern approach, are electrically operated, current being supplied at 15,000 volts from a central station at Spiez, and reduced to 250 volts. At the Kandersteg station, which is in charge of the second division, the plant includes a transformer for reducing the 15,000-volt current supply to 125 volts for lighting, and 500 volts for driving purposes. Four air compressors installed near the transformer station supply air for machine and drill working, as well as for the locomotives. Electrically operated centrifugal pumps and ventilation fans are likewise installed at this point, where there are, in addition, repair shops, explosives stores, and dwellings for the workmen. The Goppenstein plant, at the southern entrance of the tunnel, is quite similar to the former, three-phase current being supplied from a power station on the river Loetschen, at 5,000 volts.

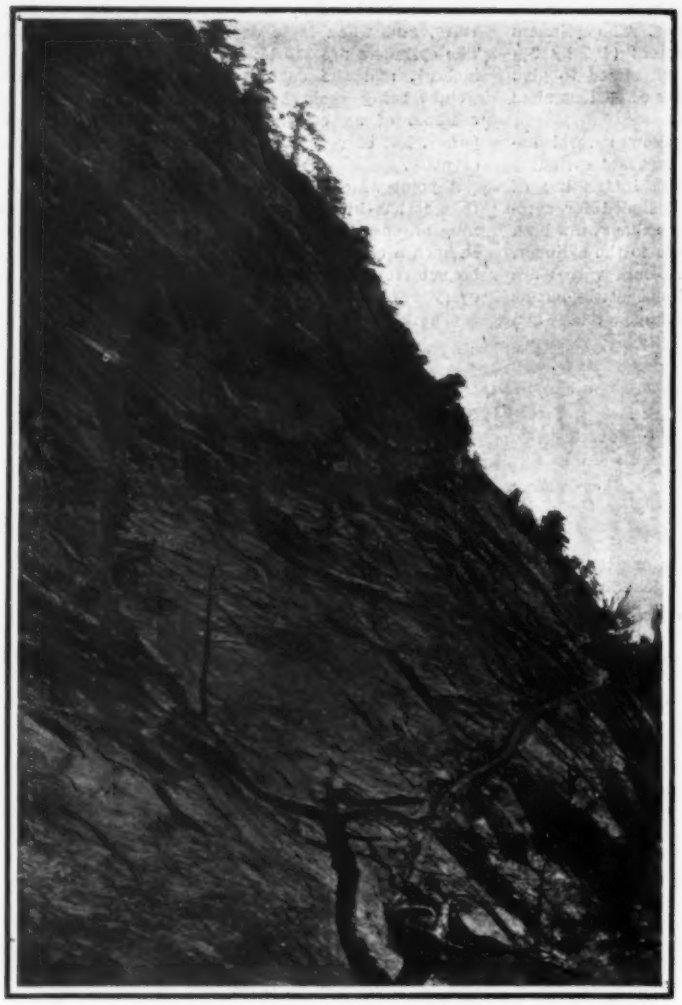
In place of the older method of conveying all supplies by mule teams from the railroad station at Giesch, a construction railroad has been built. At Brigue, which commands the fourth division, is installed a plant, similar to the Frutigen installation, single-phase current, at 250 volts, being supplied by a local company.

The tunnel will be traversed by a double-track line which, however, at both ends is combined in a single track. The tunnel is lined, as rapidly as construction allows, with a concrete 1½ foot in thickness; the extreme internal width inside this lining is to be 26 feet 3 inches. The height from the rail level to the center of the roof arch is 20 feet. A drain 2 feet square is provided at the base of the tunnel center.

A ventilating tunnel is built close to the western wall of the main tunnel; it will be rectangular in shape, tapering from the ends toward the center, and will have openings connecting to the tunnel proper, at frequent intervals. The twenty-four minor tunnels, situated along the construction railways, are all of small bore and single track.

According to reports by Mr. H. P. Kieffer, who recently visited the tunnel, the plant used in driving the main tunnel includes compressed-air drills of several types; the experience gained in the driving of the Simplon tunnel being amply utilized. The dump, as well as the workmen's cars, are handled by small compressed-air locomotives. The construction lines, leading from Brigue and Kandersteg to the tunnel portals, are of 9-inch gage, and are worked in the open by small four-coupled and eight-coupled steam locomotives.

The drills are set on a carriage consisting of a track with a wheel base of about 6 feet, which lies on the regular handling track. Mounted on this track, paral-



THIS LEDGE OF ROCK WILL EVENTUALLY SUPPORT THE MAIN LINE.

THE PERILOUS CHARACTER OF SOME OF THE PRELIMINARY WORK ALONG THE BRIGUE-GOPPENSTEIN LINE.

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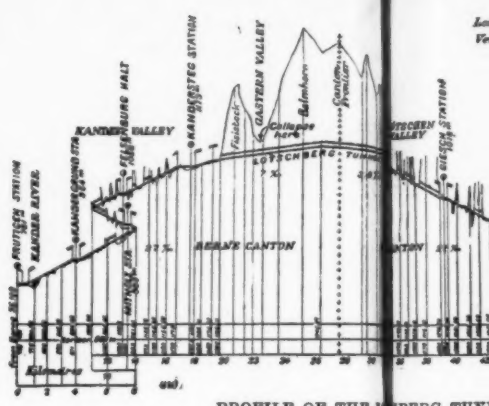
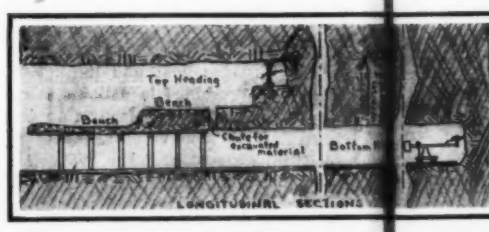
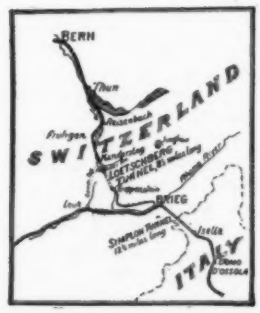


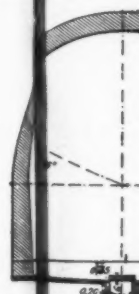
PROFILE OF THE BERG TUN



SECTIONS THR K TUNNEL



MAP SHOWING COURSE OF TUNNEL.



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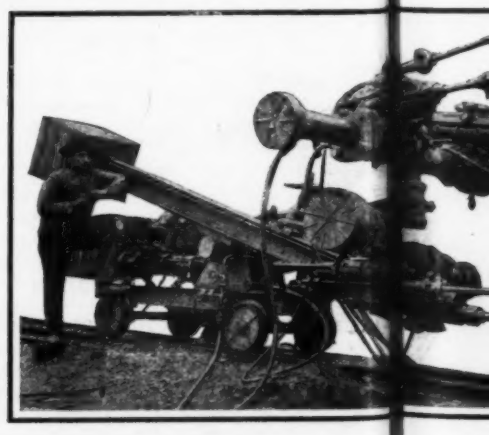
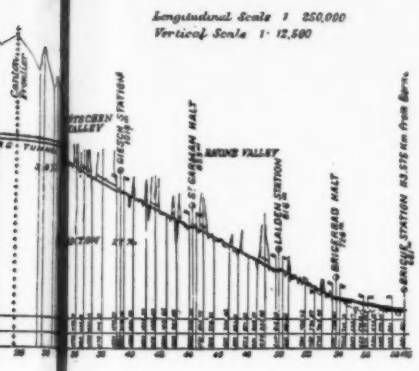


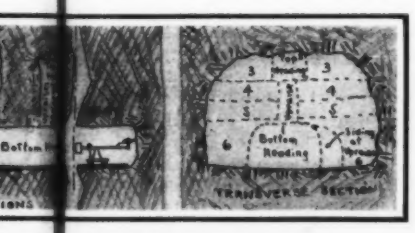
DRILL CARRIAGE CARRYING SIX DRILLS U THE BOT OF THE DRILLS BELONGING TO T RR SHAF THIS PICTU TAKEN.

THE LOETSCHBERG TUNNEL OUGH

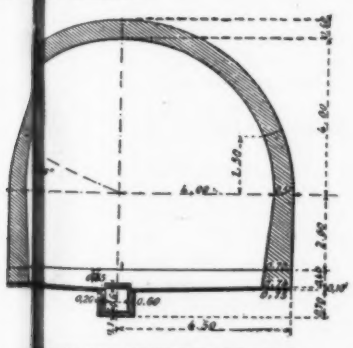
RAILR OSSES A RAVINE.



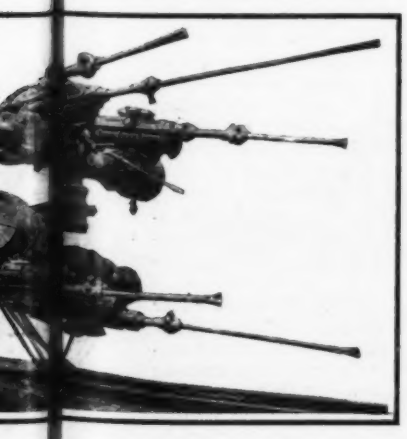
THE BERG TUNNEL.



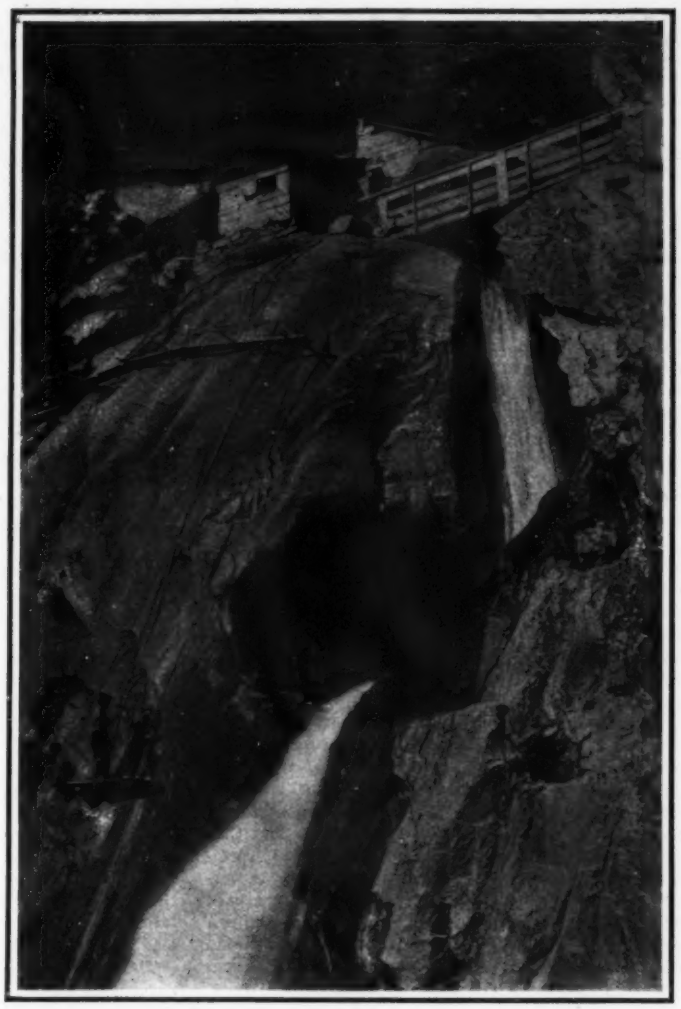
THROUGH TUNNEL.



IONS THROUGH THE TUNNEL.



LLS U THE BOTTOM TUNNEL HEADING, ONE TO TOWER SHAFT BEING OFF WHEN ICTURE TAKEN.



SCALING A PRECIPICE ALONG THE SECTION FROM BRIGUE TO GOPPENSTEIN.

A GLIMPSE OF THE MOUNTAINOUS COUNTRY THROUGH WHICH THE TUNNEL PASSES.

lel to the longitudinal tunnel, are two I-beams, hinged to swing vertically. On the forward end of each of these beams, which are substantially reinforced, there is mounted a heavy shaft bar, set transfersely, and pivoted to swing in a horizontal plane. At the opposite ends of the I-beams are counterweights. The compressed-air connections are controlled from a truck and fed from a line of hose at its rear. As the drills remain on the carriage at all times with the air connection intact, there is hardly any possibility for the dirt and grit to get into the movable parts of the drill and to impair its efficiency. The drills are of a large size, having a piston diameter of 3⅝ inches. At Goppenstein there are two electrically-driven Ingersoll-Rand compressors, giving a pressure of from 90 to 110 pounds per square inch at the drills.

Acetylene lamps, carried by the workmen, are used for lighting the tunnel, each man being expected to purchase his own lamp and to keep it in repair. As, however, the blasting blows out every lamp in the tunnel, there are many periods of total darkness just at the time when the light is most urgently wanted. Electric light would, obviously, have been far safer and much more convenient and economical.

Owing, apparently, to the very careful study made of all conditions previous to beginning the actual work, the rate of progress in Swiss tunnels is remarkable indeed. The workmen on the Loetschberg tunnel (mostly Italian laborers) number at the present time about 3,500 at both headings. The work is done in three 8-hour shifts, each shift drilling about two rounds and shooting twice, which makes an average of 6 to 7 feet per shift, or about 18 to 21 feet per day. A liberal bonus is granted to the workmen for speed above a certain rate. The work on the northern side has been temporarily discontinued, after the terrible accident which occurred last year.

The bottom heading is from 6 to 8 feet high, and about 8 feet wide. Upraises are made from the bottom heading every 620 feet, and a small top heading is started from these upraises. The work of taking out the tunnel to its full section is, then, continued from this upper heading. Horizontal benches are worked ahead, and chutes are opened to the bottom heading, out of which to take the muck, heavy timbers reinforced by steel I-beams separating the upper headings and keeping the muck from falling on the workmen below and blocking the service line. The timbering is removed as soon as the top heading is applied, and placed further in the tunnel. Solid concrete is used to bring the tunnel to its exact section.

Before blasting, a heavy sheet-steel plate, about 7 by 4 feet, is laid down just ahead of the drill carriage, at a level with the track. When the blasting is completed for one round an entrance is rapidly made through the muck pile and down to the steel plate, and it is made wide enough to allow the arms carrying the drills to get through and into the top of the heading. Drilling is begun, and the dislodged muck is taken out while this work is in progress. Thus practically no time is lost in the progress except in leaving the drill carriage and blasting. Twelve holes arranged in four horizontal rows, about 4 feet deep and 2 inches wide at the base, are usually taken in each round. When the round is all drilled, the carriage bearing the six drills is run back to the last turn-out, and the blast fired. The charge is exploded by a fuse-and-cap method, the fuses being all ignited at the same time. Owing to a careful regulation of their length they are, however, not made all to explode at the same instant. Three fuses are placed in each hole in the bottom row, and two in the others, and though a large amount of powder is used for this method, it breaks the rock up very evenly. Electrically-fired exploders have not yet been found satisfactory enough to be adopted.

Mr. Kieffer's report on his experience in visiting the tunnel is exceeding well suited to give an idea of the extraordinarily trying conditions under which a gigantic work like this is performed.

"I spent the major portion of a day in the main tunnel and several hours at the headings to watch the operations of the drills, the effects of blasting, etc. I believe I have never in my life spent the corresponding number of hours on any other work which were as nerve racking as those in Loetschberg. I stood many times knee deep in water, in total darkness, and felt the awful precussive action of the blast as the rounds were shot. The air was filled with dust, and the fumes of explosives to a degree almost to suffocation. We would hear pieces of rock falling around us as they were dislodged from the tops of the headings.

"I thought every moment would be my last. This, combined with the knowledge that one is almost in the center of a mountain with solid rock above for thousands of feet, makes one feel that it is not the safest place in the world. Little streams of water would be opened in the sides and top of the headings during the blasting, and water poured out of the almost solid rock, incidents which do not add to one's comfort."

EL OUGH THE BERNESE ALPS.

ELECTROCHEMICAL AGE.*

SCIENCE OF METALLURGY NOW ENTERING A NEW ERA.

BY ELMER E. CAREY.

FROM an examination of current scientific literature it is apparent that the science of metallurgy is now entering the electrochemical age. Copper has long been refined by electrolytic methods, and now copper sheets, tubes and wire are being made directly from copper ore by electrolytic deposition. Full accounts of this process have appeared recently in the SCIENTIFIC AMERICAN SUPPLEMENT. Electrolytic processes are destined in time to supplant all other methods in the reduction of metalliferous ores; the United Steel Corporation has adopted the electrolytic method of making steel rails, and it requires no prophet to see that the electric furnace will in time displace the various types of blast furnaces. Iron, tin, aluminium, sodium, and mercury are particularly adapted to electrical reduction; sodium is easily recovered from sea water by electrolysis. Aluminium will soon be as plentiful as iron when the various electrolytic processes now in use are brought to perfection; nitric acid is being manufactured from the atmosphere by electrical processes; feed water for boilers is being treated by the electric current to prevent scaling; drinking water is softened and purified; sewage disinfected, and the technical journals every month announce a new application of electricity or some new electrochemical process. All electrochemical processes are easily controlled; all the actions are positive; the character of the product may be altered at will; the resulting products are better in every way than those made by the older methods. Metals produced by electrochemical action are free from impurities; they are stronger, more tenacious, finer grained, and surpass the productions of the furnaces and smelters. Steel made by the electric furnace is far superior to Bessemer in every respect. The very acme of fine tool steel can be made from the black sands of the Pacific coast by means of the electric furnace, and here is the hint of an industry, now dormant, which is capable of being extended into mammoth proportions.

In the refining of gold, electrolytic methods are gradually superseding other methods; an electrolytic refining plant is in operation at the San Francisco mint. Electrochemical methods for the extraction of gold from ores were described some seventeen years ago, and during the last two years experiments have been conducted on this coast by various parties, and utility, value, and efficiency of electrochemical amalgamation and cyanidation fully established. Electrochemical action greatly increases the affinity of mercury for gold, and the action of KCn as a solvent is greatly hastened and intensified when electrochemical conditions are present.

"Within the last decade the problem of using electricity in a practical and efficient manner in the extraction of values in metallurgical processes has received the earnest attention of many investigators. It has long been known theoretically that the action of mercury and cyanide may be greatly intensified by the introduction of electrochemical conditions and inventors have been at work on the problem of constructing suitable apparatus to make practical use of the powerful aid of the electric current.

"One of the first applications of electrochemics to modern metallurgical methods consisted in suspending a plate (cathode) in a cyanide tank and recovering the values thereon directly by electro-deposition. This slight improvement was found to give an improved extraction and it is strange that the matter did not receive more attention as this advance, slight as it was, pointed the way to still greater improvements, and was a hint that should not have been overlooked.

"The next step was to electrify the entire contents of the tank, thus reinforcing the cyanide with the powerful cleansing and reducing action of electrochemical forces; with proper electrolytic conditions it was found that the percentage of extraction is much higher and the time of treatment much shorter; and at the same time, as the values pass into the solution, they are simultaneously deposited on the amalgam plate by the electroplating action of the current, and the cyanide released for another cycle. The great efficiency of this system over the usual cyanide methods has been fully demonstrated; it is quicker, more positive, extracts a higher percentage of value, costs less to install and to operate, and in addition will extract values from pulp which is not susceptible to the action of ordinary cyanide solutions.

"Turning to amalgamating practice, it may be said that electrochemical methods may now be successfully used in connection with the usual battery plate. After a long series of experiments, extending over a score of years, a very simple method of converting the standard plate into an electrochemical amalgamating device of remarkable efficiency has been devised. The electrochemical system of amalgamation is designed to extract from the sands or pulp all gold values not incased; it is entirely a new system of amalgamation, designed to do the work of the ordinary mill plate, including the treatment of slimes, and at the same time to extract values which cannot be saved by the usual mill practice and which otherwise would require cyanide treatment; to do all this in one single inexpensive and continuous operation, requiring practically no more outlay for installation and maintenance than the usual mill plate. The system also furnishes a method by which the Alaska beach deposits, black sands, hydraulic, placer, and dredge tailings, mill tailings, desert deposits, and many low-grade propositions can all be profitably worked. The broad claim made for the electrolytic system is that it will save all values not incased.

"*Preliminary Treatment.*—It may be sometimes necessary to grind ore or sands to 100, 150, or even 200 mesh, before the values are released, but after this has been done, the pulp is simply passed over the amalgamating device, and the electrochemical forces automatically extract the value to such an extent that usually no further treatment is profitable. In ordinary cases, values are recovered at 80 mesh. In certain cases where the ore is unusually refractory, base or rebellious, it may be necessary to treat the tailings for an hour or two by the continuous electro-cyanide process, which is an exceedingly simple and inexpensive operation, but withal very efficient.

"*Mode of Construction.*—The electrolytic method of amalgamating calls for a sluice box of suitable width, the length being 40 or 50 feet, or even longer according to conditions. In the bottom of the box is an ordinary copper plate acting as a cathode. Graphite anodes of suitable construction are arranged to conduct the low-voltage current into the water (electrolyte) passing over the device. Pulp of proper fineness, screened gravel or sand is passed into the apparatus by suitable means. Certain solutions are also added to the water. A critical low-voltage current of proper amperage is passed into the anodes; the water carrying pulp, etc., acts as an electrolyte, and makes the electric connection with the copper plate (cathode). In operation the water is at all times electrified and the copper plate is also constantly under electrical action. The device can be made of any desired capacity.

"*Essential Elements of the System.*—So far as the electrochemical actions and processes are concerned, there are five cardinal conditions or points to consider:

"(a) The anodes.

"(b) The flowing body of water, pulp, slimes, etc. (electrolyte).

"(c) The copper plate (cathode).

"(d) Certain solutions added to the water:

"1. Mercurial solution.

"2. Sodium solution.

"3. Hydrogen solution.

"(e) Low voltage current.

"The anodes and cathodes are connected with a 5-10 volt generator in the usual manner; the usual volt meter, rheostat, and ampmeter being in place. The current used has approximately the density of about five-tenths of an ampere per square foot of cathode surface."

In operating the mercury solution is mixed with water passing into the device. The amount of the solution, which is standardized, depending upon the values in the pulp. About the same amount of mercury is needed as in the ordinary practice. Practically all the mercury is recovered in the amalgam. Several chemical, electrical, and electrochemical processes are constantly and simultaneously in operation. When the machine is once adjusted for given conditions, these processes and reactions are synchronous, automatic, and mutually balanced, all of them combining perfectly to assist in the recovery of values. In this system the various powers, affinities, and laws of electro-chemics have been perfectly balanced and harmonized to produce certain desired results, and the system beautifully illustrates how natural laws may be used to serve mankind when intelligently adjusted and applied. A few more important reactions will now be mentioned.

Intensified Chemical Action.—All chemical action is greatly intensified under critical electrical conditions. Amalgamation is a chemical action, and the affinity of mercury for the metals is greatly quickened by the electric current. The chemical processes described below are much more rapid and effective under the electrolytic conditions than they usually are. In a similar manner the action of a cyanide solution can be greatly augmented and intensified; in electro-cyanidation values are recovered which are refractory in the usual solutions; and the time of treatment is reduced to one or two hours, while the gold is recovered by electro-deposition in the form of amalgam.

Deposition of Mercury.—The even, constant and uniform deposition of virgin (nascent) mercury on the cathode plate is the crucial operation of the system. The mercury is deposited from the mercuric solution mentioned above by ordinary electrolytic action; an electro-plating process is in operation, and we have the cathode plate covered with a bright, uniform and chemically pure coating of nascent mercury, which remains in a perfectly "healthy" state as long as working conditions continue. The deposition of mercury and the character of the amalgam are at all times under absolute control of the operator. The mercury coating or plating adheres tenaciously to the copper plate, and the passing volumes of water, sand, pulp, etc., have no effect upon it. With proper adjustment, no excess of mercury is possible, and no "floured" mercury is discernible in panning the tails. This coating or plating of mercury above mentioned will stand the action of a heavy volume of running water containing a full load of pulp; even water carrying a full load of magnetic iron has no injurious effect upon it.

The mercury deposited by electrolytic action is nascent or virgin mercury; its affinity for metals and gases is far greater than usual; its amalgam forming powers are intensified to such a degree that rusty, greasy, or pyritic gold is instantly amalgamated; platinum is absorbed as quickly as gold when sodium is present in the amalgam (see Sodium Amalgam). Grease, talc, silicious coatings, or sulphurous conditions in connection with gold particles have no effect in preventing amalgamation, and "fouling" or "sickening" of the plate is impossible. The use of electrolytic amalgamation insures at all times a constantly bright, healthful, and powerfully active mercurial surface, impossible under the usual practice. The behavior of the mercury under electrolytic conditions is entirely different from its action in ordinary amalgamating practice; and conclusions based on the usual mill practice will not apply in the new method.

Nascent Hydrogen.—Hydrogen at the moment of its liberation from a compound is known as nascent hydrogen; the gas in this condition has much more powerful affinities than ordinary hydrogen; nascent hydrogen has increased powers as a reducing agent; it destroys instantly organic, greasy, and foul conditions; it unites instantly with the oxygen of iron rust at ordinary temperatures, thus cleaning "rusty" gold; all impurities in the water are counteracted, and the action of nascent hydrogen on the mercury is such that fouling of the plates cannot occur. One authority states that in the presence of nascent hydrogen, mercury cannot "sicken" or oxydize or become sulphated.

The action of nascent hydrogen as a cleanser and reducing agent is used to advantage in the electrochemical amalgamator, and if the gold particles are unusually coated or rusty, additional volumes of hydrogen can be obtained through electrolysis by adding some inexpensive solution of potassium or sodium. Under the action of electrolysis, the mercury as fast as deposited, absorbs free hydrogen, which is occluded throughout the whole mass of mercury; large volumes of hydrogen are thus absorbed, and the gas is all the time exercising a powerful cleansing and reducing effect, and preparing the way for amalgamation. Mercury, which has absorbed hydrogen under these conditions is in the best possible condition to form amalgams.

Formation of Sodium Amalgam.—When sea water is used in the electrolytic system of amalgamation, or when a solution of common salt, or some solution containing a sodium salt is mixed with the water entering the device, we have the deposition of nascent metallic sodium by electrolysis; nascent sodium is brought into contact with nascent mercury, and a sodium amalgam is formed, which is absolutely pure chemically; we may say sodium amalgam in its "nascent" state is formed, in which state it must always remain healthy; it also in this state has a much stronger affinity for the metals than the usual sodium amalgam of the arts. Sodium amalgam will hold free gold in any condi-

* The Los Angeles Mining Review.

tion; also platinum; at least hydrogen-sodium amalgam will amalgamate all metals not incased, which are in a comminuted state and sodium amalgam by electrolysis cannot be made without the presence of hydrogen. Free sodium also destroys organic substances, and acts as a general cleanser in the chain of operations.

Hydrogen-Sodium Amalgam.—In volume 1, Proceedings of the London Inst. Min. and Met., page 205, will be found an article by P. C. Warnford Lock, E. M., in which he describes the formation of hydrogen-sodium amalgam and mentions the powerful affinity between this amalgam and gold. In electrolytic amalgamation the hydrogen is formed in several ways:

(a) By the electrolysis of H2O.

(b) By the electrolysis HgCl 2.

(c) By the electrolysis of various salts, which may be used for the formation of hydrogen.

Part of the hydrogen liberated is occluded by the mercury forming hydrogen-sodium amalgam, and part is used in reducing oxides which form rusty coverings on gold particles; part also act as a general cleanser and purifier as it escapes through the water. In leaving this paragraph, I would remark that in an amalgam of hydrogen, sodium, and mercury formed under nascent conditions, we have a trinity of the most powerful amalgamating agents at present known, and amalgamation will take place even in the presence of silicious coatings, rusty, sulphurous, greasy, arsenical, pyritic conditions, or other adverse conditions which usually prevent amalgamation.

Formation of Gold Amalgam.—We have seen above how the presence of hydrogen and sodium prepares the way for amalgamation. So well has the work been done that amalgamation takes place as soon as a particle of gold touches the quickened mercurial surface. And it might be noted in passing that amalgam formed under the conditions which we have described (electrolytic amalgamation) is a different compound from the usual amalgam formed on mill plates. The amalgam as described holds to the plate very tenaciously as it is placed there by electrolytic action, and it is not easily dislodged. It is homogeneous, tenacious, and free from foreign materials. Particles of amalgam under this system are not broken off by the passing volumes of water. The larger particles of gold will come in contact with the mercury before passing many feet; microscopic values or float gold, or values in slimes will require a longer length of cathode surface; at times possibly 40, 50, or even 60 feet will be required, but any microscopic particles, or any of the values in slimes will be instantly arrested at the first contact with the mercurial surface. Microscopic values and fine particles of gold in suspension are coated with mercury the moment they enter the zone of electrical action, and the cataphoretic action of the electrical current assists in forcing them into contact with the mercurial surfaces. Experiment has demonstrated that electrolytic amalgamation will recover from 95 to 99 per cent of all gold not incased, and in many cases the extraction reaches 100 per cent. Usually when the pulp of refractory ores is ground to 100-200 mesh, the tailings after passing the electric amalgamator, do not contain enough values to make any form of supplementary gold-saving devices necessary.

Electrolytic Amalgam.—Amalgam found under the above described conditions is electrolytic amalgam or "nascent amalgam"; it is formed by particles of gold which have been cleaned and coated with an electroplating of mercury, coming into contact with nascent mercury. The resulting amalgam has entirely different qualities from the usual mill plate amalgam. Electrolytic amalgam is soft, smooth, homogeneous, elastic, tenacious yet plastic; it cannot be eroded by passing volumes of water and pulp; it does not crumble; it is never sulphated; it contains no foul conditions; it forms an ideal surface for the absorption of any passing particle of gold of amalgam; it is "alive," has the greatest possible affinity for gold, and no mill man ever saw a more beautiful and perfectly "healthy" amalgamating surface, for the electrolytic amalgamating surface is, metallurgically considered, the acme of perfection.

Chlorine Gas.—Nascent chlorine is liberated when common salt or bichloride of mercury are electrolyzed in solution; chloride water is formed; chloride under such conditions cleans and brightens gold by reducing the oxides; chlorine and hydrogen also unite to form hydrochloric acid which attacks all kinds of impurities attached to gold particles. Chlorine gas is the most powerful bleaching agent known. It is possible that microscopic particles of gold in slimes may unite with chlorine or hydrochloric acid and form compounds, from which gold is liberated, and deposited on the cathode plate by electrolysis.

Electrolysis of H2O.—The decomposition of water has been mentioned and the action of free hydrogen described. Nascent oxygen is liberated which also assists in preparing values for amalgamation. Oxygen in this state is a powerful enemy of organic substances, and foul, greasy, or dirty conditions are quickly eradicated by its action.

Mechanical Action of Gases.—At all times there are liberated from every portion of the surface of the cathode free gases which arise upward through the water. These constantly escaping gases have a tendency to act as a cushion over the newly-formed amalgam, which cushion prevents in a measure any scouring effect on the part of both sand or gravel, thus rendering the system equally applicable to stamp mills, placer mines, gold dredges, and beach mining. Gravel and black sand can be passed over the device, and freed from all values, no matter how small, which may be present.

Dynamic Electrical Action.—The claim is made that a critical electrical current when properly adjusted tends to force all gold particles to the cathode plate, and that such current actually does carry microscopic particles into contact with mercury; and that the efficiency of this force depends upon density, voltage, and proper adjustment of the device. There is considerable evidence to support this contention that there is a dynamic action in the electrical current which carries gold particles to the cathode. As a rule, all values are deposited in the mercury in the first ten or twelve feet of plates; and it is hardly reasonable to suppose that gravity alone would be sufficient to force every particle of gold into an amalgamating contact in such a volume of water as is used. If the necessary contact for amalgamation was the result of chance and gravity, it would be reasonable to look for an occasional color in the tailings; but not only is it impossible to find a color there by the most careful pannings, but it is impossible to find any value of importance by the most careful assay. In view of this fact, and other facts which have been noted, it is reasonable to suppose that there is a dynamic quality in the electric flow which acts directly upon metallic particles of gold; and as Madam Curie and other scientists have pronounced electricity to consist of material ions, this view is not entirely without foundation.

In the system of gold extraction above outlined amalgamation proceeds under the most favorable conditions that can be provided. Every obstacle is removed, and every force that tends to assist is intensified and reinforced. Not in a laboratory could a more positive action be obtained. Instead of leaving the amalgamation process to chance and the uncertainties of the usual practice with all attendant difficulties, we have in the process in question, the formation of amalgam carried on under ideal conditions, where the highest possible efficiency is attained; and it should be remembered that the processes and forces which deposit the mercury and gold in the form of amalgam are constantly striving to hold the amalgam in place, and to resist any erosive tendencies of the water and pulp. The amalgam coating is the result of the electroplating action of the device and the amalgam is forced into a perfect contact with the copper plate. In view of these facts it is not unreasonable to believe, that in the near future, electrolytic amalgamation will supersede the older methods, and at the same time vast fields will be open for the miner which are now beyond his means.

There are vast ledges and mountains of low grade and refractory ore, which, with the improved grinding machinery, in connection with electrolytic amalgamation, may develop into immense mining fields with a gold output far greater than the present yield of precious metals. For locked up in the immense ledges and deposits of low grade ore, found in all gold-bearing countries, we have a treasure house containing values easily accessible, a thousand times greater than the combined wealth of the nations. When the limited supply of gold from the few high-grade veins is exhausted it is to these vast deposits that the world must turn for its supply of metals for monetary purposes.

The only special machinery required for the electrolytic system of amalgamation is a low-voltage generator requiring from 2½ to 5 horse-power for operation. A 5-horse-power generator will furnish sufficient current for the treatment of 500 tons daily.

THE PNEUMATIC TIRE AND THE AEROPLANE.

IT seems a far cry from the bicycle tire to the aeroplane in the sense that the former is to any degree concerned with the development of the latter, but, according to one who has given the matter some serious thought it appears that the connection between the pneumatic tire and the flying machine can be logically established. The fact that the automobile is an intermediary in the evolution that has made the latest mechanical triumph possible is interesting now, and it will not be unprofitable to briefly trace the evolutionary process that has made flight actually possible under favorable conditions, and which has aroused high hopes of making it a practicable means of travel.

The early bicycles of the high-wheel variety was facetiously named "bone-shakers," and bone-shakers they were in truth. The bicycle was only moderately popular in favored places having smooth roads and specially constructed tracks, until the advent of the "safety" and pneumatic tire. The new tire transformed the bicycle from a hard-riding machine, extremely fatiguing to all but those of strong physique, to a vehicle of business and pleasure for young and old of both sexes.

The wonderful improvement in riding quality made in the bicycle by the pneumatic tire stimulated the efforts of inventors and designers to produce a practicable four-wheel carriage driven by power, to replace the horse-drawn wagon, and the "tires of air" literally smoothed away some of the great difficulties that had made the horseless wagon impracticable before.

When the running-gear problem was in a fair state of development, attention was concentrated on the motive power, and after a few years of strenuous competition the steam engine gave way to the internal combustion motor which won out because of its simpler control, higher efficiency and greater power per unit of weight. To-day the automobile gas engine is the world's wonder for concentration of power and simplicity of construction. In the space occupied by a Saratoga trunk can be placed a motor capable of generating 40 to 50 horse-power and weighing only from 8 to 10 pounds per horse-power.

Observers of birds and bird flight long ago took note of the strength of their wing muscles and apparent ability to exert great muscular effort in proportion to weight. Whether birds actually exert much power to sustain themselves, when once in flight is a mooted question, but it is easily proved that they must expend great effort in the first few moments when rising in the air and getting in motion.

The heavier-than-air flying machine requires a powerful, light motor to launch it into the atmosphere and to sustain motion. The gas motor developed to meet the needs of the automobile required only further development to fit the special needs of aviation. As a matter of fact that development has been going on simultaneously in automobile, motor-cycle and aeroplane motors, and the leaders in mechanical flight might well contend that their share in the development of the gas engine is by no means small. Whether the chain of events thus outlined actually put the aeroplane in debt to the pneumatic tire we shall leave to our readers to decide for themselves; but whatever the conclusion, the tracing of mechanical developments to imagined or real sources leads to some curious discoveries. One is forced to believe that many of the apparently trivial devices, in their infancy, have been the germs from which the most important developments have come.—Machinery.

THE SCIENCE AND ART OF STOKING.

J. IZART, in L'Electricien, asserts that, although mechanical stoking sometimes produces better results than hand stoking as ordinarily performed, still better results can be obtained by a perfect method of stoking by hand. He suggests a system of technical instruction, rewards and fines or dismissals, by which the efficiency of stokers may be increased. The instruction should include the following precepts: to add fuel very often and in very small quantities, to use as little draft as possible, to touch the fire rarely and only to make it uniform, never to poke it. The normal rate of combustion, when fuel is added at intervals of from 4 to 8 minutes, is about 15½ pounds per hour per square foot of grate.

Except for highly bituminous coal the ordinary method of distributing the fuel over the whole grate is preferred to the English system of keeping the fire at the back. The depth of fuel should be from 3 to 3½ inches.

Rewards should be based on the average percentage of carbon dioxide found in the fuel gases during 12 hours. This system is in operation in the Apollo candle factory in Schiedam, where the gases of the twelve furnaces are tested continuously and separately by the Waller apparatus. A reward of 2 cents per furnace per hour is given for 9 per cent of carbon dioxide, 6 cents for 15 per cent, and proportionate rewards for intermediate percentages. The result is that about 12 per cent are usually produced.

The work of the stoker can be controlled by means of Bruyn's depressometer. This apparatus consists of a cylinder, half filled with water, with a tube passing through the bottom of the vessel and extending above the water. The upper end of the tube is covered by a cup the edges of which are below the water level. The upper part of the cylinder, in general, is in communication with the external atmosphere, but the space within the cup is confined and the pressure in that space depends on the intensity of combustion. This pressure is indicated by a gage which is connected with the lower end of the tube, and which may be arranged to make a continuous record on a moving band.

MEMPHIS AND ITS FOREIGNERS.*

THE PRELIMINARY WORK AT ATHRIBIS.

BY PROF. W. FLINDERS-PETRIE

THE opening of the mounds of the great capital of Egypt is the largest enterprise yet started in Egyptian excavation. To clear the sites of the temples only, will probably take twenty years to complete, and 400 or 500 workers are employed during the dry season when the water level has subsided. Beside the temples the city itself is of great interest as a commercial and manufacturing center of civilization. The Egyptian Research Account has undertaken this work for solving as its means and opportunities will allow. Each year two preliminary months are spent on drier ground until Memphis is in condition for the three months' work which is practicable each year.

The preliminary work of 1907-08 was at Athribis near Sohag in upper Egypt. A temple was unearthed there about the size of the well-known temple of Denderah, and as much as 12 feet of the sculptured walls still remain in some parts. It was built by Ptolemy XIII about 600 B. C., and finished under Hadrian about 130 A. D. Another temple site of Ptolemy VIII was also found. In the cemetery is a very curious tomb with two horoscopes painted on the ceiling; these are the only examples of colored zodiacs of Roman age, and we traced them and published them in colors. Near by is a cemetery of the pyramid age, with dozens of tombs cut in the cliffs about 500 feet up. Four of these which were sculptured we copied; they are peculiar in some points, such as a man having six wives, an instance of polygamy as yet unknown in ancient Egypt.

The main work was at Memphis, on several parts of the site. The great temple inclosure of Ptah was traced around, defining the brick wall of Rameses II deeper, thus finding hundreds of tablets and fragments of the eighteenth dynasty, underlying the Ramesside building. Many of these had figures of ears upon them; and the inscriptions, calling on the god Ptah to hear prayers and petitions, show that the idea of these was that the ears were those of the god to receive and hold the prayers. Sometimes there is only a single ear and nothing more; in the tablets are two or more ears, and one has 376 ears upon it. These give an interesting light on the beliefs and practices of the Egyptians. The same site will be further excavated this year.

PERSIAN GREAT KING FROM MEMPHIS.

Another large building was found, of King Siamen, 1000 B. C., of whom scarcely anything was known before. Two of the sculptured lintels are now in Philadelphia and Pittsburg. Another building of Siamen

FIGURES OF SCYTHIANS FROM MEMPHIS AND SCYTHIAN FROM KOULOBA VASE (UPPER LEFT CORNER).

which ran one-third of a mile in length and one-quarter of a mile in width. This area is equal to that of the great temple of Amen at Thebes, and it was doubtless filled with buildings like the temples at Thebes. A part where ruins were already visible was cleared was found beneath the house of the Research Account, a whole column 13 feet high still standing on its base.

The most interesting site from a western point of view is that of the foreign quarter, which was identified by the quantity of early Greek pottery, and the position described by Herodotus. Here we found the site of a temple built by Merenptah; this is almost certainly that of Proteus, according to Herodotus, which contained the shrine of the foreign Aphrodite. Here are unearthed the great outer gateway; half of the fore-court and the doorway which led into the temple. It is the work of 1909 to clear the temple site itself. The pottery found here is foreign and all about the site are found pottery heads of foreign types.

The heads, which we illustrate here, seem to have been made first during the Persian occupation, about 500 B. C. The earlier ones are all hand-modeled and solid; later, about 300 B. C., figures were made in a mold, but still solid; and probably about 200 B. C. begin the hollow molded figures, which continued to be made down to late Roman times. The heads of the Persian Great King and the cavalry officer are unmistakable. A Syrian Semite is exactly like that in the tombs at Benihasan. Other heads are of the types of the Sumerian Babylonians, showing that the race continued although the language was changed to Semitic. The Scythians on horseback with their tall, pointed hoods are just the same as on the Crimean vases. While Indian heads and figures are also found here of the Tibetan and of the Aryan stocks, showing how both the extremes of the Persian empire, Scythian and Indian, were brought together in Memphis, as we know they were in the Greek war. The importance of the Indian colony in Memphis under the Persian empire lies in its bearing on the importation of Indian thought, and the rise of the ascetic movement before Christ which culminated in western monachism. The whole of these heads are published in the annual volume "Memphis I," which is just ready for issue.

The present year's work has also been very successful at Thebes and at Memphis, where the palace of Apries and the temple of Proteus are both being now cleared. An account of these will appear in the future. Everything found in the work of the Research Account is published as soon as possible in the annual volumes which are given to subscribers, who can remit to Dr. Winslow, of Boston, or to University College, London.

* Records of the Past.

THE BITTER QUARRELS OF DISCOVERERS.

IT seems to be the fate of great explorers to quarrel over their discoveries, and to have their right to credit for them disputed. In fighting over the honor of having discovered the North Pole, Cook and Peary are but following in the footsteps of Speke and Burton, whose fight over the discovery of the source of the Nile embroiled the scientific world for many years. The misfortune of Cook in having his statements questioned is but that of Bruce. Had there been telegraphers and newspapers in the fifteenth and sixteenth centuries, they would have been filled with just a row as this over the rival claims of Christopher Columbus and Amerigo Vespucci to have discovered America, and as to whether Verrazzano or Hudson or Gomez first discovered the Hudson River.

James Bruce's fate was enough to embitter almost any man. After ascending the Blue Nile to its source in the Ruwenzori Mountains, or Mountains of the Moon, in 1766, he reached Marseilles in 1773, and there met D'Anville, the great French geographer, who told him that what he had discovered was interesting but not new, in proof of which he showed him a map which D'Anville had published in the preceding year, based upon sketch maps made by two Portuguese Jesuit priests, Father Paez, who had explored this very ground in 1615, and Father Lobo, who had gone over it in 1625. Paez's map had been published in 1652, and Lobo's in 1670. It was rather a shock to Bruce to find that instead of discovering what had been sought for centuries he was merely an "also ran."

But worse was yet to come. He published an extremely interesting account of his travels in Abyssinia and central Africa, and in it he described many of the extraordinary customs of the people, including their fondness for live beefsteak cut from the living animal and eaten before the flesh had cooled or ceased to quiver from the pain of the knife. His book was hailed with derisions; he was compared to Herodotus as a writer of more imagination than truth. Dr. Johnson denounced him as an "unscrupulous romancer," and Horace Walpole said his book was "dull and dear." But Bruce's statements have been verified, and his book is as good reading to-day as it was 130 years ago.

The Nile has two branches, the Blue and the White. The source of the former settled, explorers turned their attention to the latter. It was not until the middle of the last century that the problem was

attacked in a scientific manner. How the real source was discovered, and what a disagreeable quarrel arose from the discovery is told by Sir Harry Johnston, in his book, "The Nile Quest." Sir Richard Burton and John Hanning Speke together discovered Lake Tanganvika in 1856, and surmised it was the source of the Nile, but the natives told them that no river ran out of that lake. The river Rusizi, however, ran into

BABYLONIAN SEMITE HAMMURABI. BABYLONIAN (?) FROM MEMPHIS.

TERRA COTTA HEADS OF FOREIGNERS FROM MEMPHIS COMPARED WITH OTHER TYPES.

it. Then Burton became ill, and Speke determined to explore still further.

"Burton yielded his consent reluctantly," says Sir Harry Johnston, "and appears to have given but grudging assistance in the way of men and guides. Full of energy, however, Speke gathered together a caravan, which crossed Unyamwezi and Usukuma, and on July 30th, 1858, he saw the Mwanza Creek, one of the southernmost gulfs of the Victoria Nyanza. Traveling northward along this creek, on August 3rd, 1858, early in the morning, Speke saw the open waters of a great lake with a sea horizon to the north. Much of the horizon was shut in by great and small islands, but Speke detected through their interstices the vast extent of open water which stretched to the north.

"He realized to the full the wonder of his discovery, and the obvious probability that this mighty lake would prove to be the main headwaters of the White Nile. . . .

"Unable to delay longer in his exploration of the southern shores of the Victoria Nyanza, as he had promised to rejoin Burton by a certain date, Speke returned to Kaze in Unyanyembe, to find his companion vexed at the great discovery which he had made. Speke did not pursue the argument as to the Victoria Nyanza being the main source of the Nile. The two men journeyed together on more or less bad terms to Zanzibar, where Burton remained to wind up the affairs of the expedition, Speke returning direct to England.

"Burton returned to England in 1859, somewhat chagrined to hear of the enthusiasm with which Speke's discovery of the Victoria Nyanza had been received—an enthusiasm which, to some extent, had put the revelation of Lake Tanganyika in the shade. Burton nevertheless was awarded, in 1860, the gold medal of the Royal Geographical Society, and in returning thanks for the honor, he uttered a handsome acknowledgement of Speke's services as surveyor on the expedition to the great lakes. But the two men were evidently on bad terms, and though the fault of their disaccord may have been with Burton's conduct, the world knew it first through the writings of Speke in 'Blackwood's Magazine,' and later (in 1864) in the reproduction of these Blackwood articles with additions under the title of 'What Led to the Discovery of the Source of the Nile.' In these works Speke makes some stinging references to Burton. . . .

"Burton's own attacks on Speke scarcely appeared in a public form until four years after Speke had returned to Africa. . . . Burton's chief revenge lay in endeavoring for many years to prove that Speke had made no very great discovery; that his Victoria Nyanza was not the greatest lake in Africa, and the main source of the Nile, but a network of swamps and lakelets."

This controversy was waged for years. In 1862 Speke verified his theory that Victoria Nyanza was the source of the Nile by discovering Ripon Falls, the spot at which the river leaves the lake. On his return to England in 1864, the British Association arranged that he and Burton should debate their different views as to the Nile sources on September 15th, at Bath. But this debate never took place, for the very morning of the day set, Speke was killed while out partridge shooting. Stumbling over a stile with his gun at full cock, the gun was discharged, and the contents of both barrels entered his body.

It was not until 1875 that Sir Henry M. Stanley settled the point, by exploring the Victoria Nyanza, and proving that Speke was right in asserting it to be the greatest lake in Africa, and the source of the main branch of the river Nile.

It is the irony of fate that though Columbus discovered America the continent should be called not after him but after Amerigo Vespucci. According to the latter's own story, which is the only authority the world has for the assertion, Vespucci was the first to discover the mainland of North America, having reached here in 1497, several months before either the Cabots or Columbus. Columbus's discovery was what started Amerigo Vespucci to voyage westward. There were many who then disputed Vespucci's claim to priority, just as some scientists are disposed to cast doubt upon Cook's claim to have been the first man to reach the North Pole, but the fact remains that the continent bears his name and not that of Columbus. The firm in which he was a partner fitted out Columbus's later expeditions, and it was with one of these that Vespucci sailed, just as it was with Peary that Cook first sailed to the Arctic. However, the continent is named America and not Columbia.

Another notable instance of a real discoverer losing credit for his achievement is that of Verrazzano. That he really discovered the Hudson River in 1524 is a historical fact, proved by his log and by letters of his which are still extant. How far up the river he sailed is a matter of doubt; but it is certain that he sailed into New York Bay sufficiently far to see and describe Manhattan Island. Hudson explored the river that bears his name eighty-five years later, in 1609. The reason that Hudson received the credit for it is to be found in the fact that the early settlers were Dutch and English. They knew all about Hudson; few, if any, of them had ever heard of Verrazzano. Eager to claim credit for a man of their own race, historians dismissed Verrazzano with a line, while they told the full story of Hudson's discovery.

All of which does but go to show that Cook and Peary are not the only explorers who have been rivals or whose discoveries have been called in question.—English Mechanic and World of Science.

TIBETAN TYPE. ARYAN TYPE.

TERRA COTTA FIGURES OF INDIANS FROM MEMPHIS.

COSMIC INFLUENCES AND HEALTH.

WHEN regard is had to the number and intensity of great cosmic influences which are at work some wonder may well be expressed that the physical conditions of the world are as steady as they appear to be. It is only recently that the existence of fresh manifestations of forces affecting the earth has been realized, and it would be rash to say that of these manifestations there is no end. A few weeks ago we were told by our telegraph authorities that the whole earth was visited by a great magnetic storm. There were sudden rapid oscillatory movements of the magnetic needle, so erratic in character that the tracing could no longer be registered on the recording sheet, and in many instances the telegraph service failed. The duration of the storm was comparatively short, but while it lasted it exhibited an energy which has very seldom been rivaled. The year 1909 has so far been characterized in many parts of the world, including this country, by a very disturbed state of weather which has been uncongenial to everyone's health and comfort, and there are well recognized authorities who trace this unpleasant fact to sun spots, the most recent of which has been calculated to be hundreds of thousands of miles in area. Magnetic storms have been ascribed to the same solar phenomenon, to a savage outburst of incandescent gases, and the world has been treated to a deluge of electrons, each carrying its electric charge to effect disturbances in the media they travel through, bringing about among other things the beautiful phenomena of the aurora and the magnetic storm. All this is interesting, and the interest intensifies when we consider that it is possible that these cosmic forces may have a profound influence on the health. No one can deny the peculiarly distressing effects which an impending thunder storm has on some people and the relief they experience when the storm has spent itself. Many people assert that they experience a thunder storm headache and can predict with confidence when the atmospheric stress is

about to be relieved. It is also a fact, and not a rustic piece of credulity, that beer or milk "turns" under these conditions, but no satisfactory explanation appears to be forthcoming of these events. They are, however, not more obscure than the colic, sickness, and diarrhœa which sometimes accompany electrical states. When we follow this vein of thought we become reluctant to deny the accuracy of many so-called superstitions. It is quite incredible, for example, that some persons cannot sleep unless their body lies in the direction of the magnetic meridian or across it, as the case may be? The conviction of this idiosyncrasy here and there has been so strong that revolving beds have been made which could be turned to the position conducing best to sleep. No one doubts that by some subtle power the moon influences the tides, and there is the probability of the existence of other cosmic influences of which so far we know little, yet which may interfere with our well-being. Certainly our well-being is disturbed by weather, and in that way, at any rate, we may trace certain disturbances of health to sun spots, since there seems to be little doubt that the meteorology of the earth is affected by them.—Lancet.

RECENT PROGRESS IN CHEMISTRY.*

NEW THEORIES OF THE STRUCTURE OF THE ELEMENTS.

BY PROF. H. E. ARMSTRONG.

IN 1885, in defending the tendency of chemists to devote themselves to the chemistry of carbon, I could speak of the great outcome of their labors as being the establishment of the doctrine of structure. Everything that has happened in the intervals is in support of this contention. It is interesting that in a recent lecture† on the Physical Aspect of the Atomic Theory, the most prominent living exponent of physical theories has given a not unwelcome recognition of our right-mindedness in saying: "As time goes on it becomes increasingly difficult to resist the direct evidence for the simple view that, in many cases, chemical combination is not so much a fusion or intermingling of the combining atomic structures as rather an arrangement of them alongside one another under steady cohesive affinity, the properties of each being somewhat modified, though not essentially, by the attachment of the others; and that the space formulæ of chemistry have more than analogical significance." And again the following passage, in which a far-reaching confession is made: "The aim of structural chemistry must go much deeper (than dynamical methods of treatment); and we have found it difficult, on the physical evidence, to gainsay the conclusion that the molecular architecture represented by stereochemical formulæ has a significance which passes beyond merely analogical representation and that our dynamical views must so far as possible be adapted to it." The remark made by Helmholtz in one of his letters, "that organic chemistry progresses steadily but in a manner which, from the physical standpoint, appears not to be quite rational," must be regarded as little more than a confession that he was out of his depth. When properly understood, nothing could be more rational and logical than the way in which our theory of structure has been gradually built up on an impregnable basis of fact, with the aid of the very simple conceptions of valency postulated by Frankland and Kekulé. Our security lies in the fact that the postulates of our theory have been tested in an almost infinite variety of cases and never found wanting; this is not to say they are applicable in all cases, but merely that whenever we are in a position to apply them we can do so without hesitation. Larmor refers to the habit of physicists of taking comfort in Helmholtz's remark; it will be well if instead they make themselves acquainted with our methods and with the results we have won, with a minimum of speculative effort, by the cultivation of an instinct or sense of feeling which experience shows to be an effective guide to action. Now that physical inquiry is largely chemical, now that physicists are regular excursionists into our territory, it is essential that our methods and our criteria should be understood by them. I make this remark advisedly, as it appears to me that of late years, while affecting almost to dictate a policy to us, physicists have taken less and less pains to make themselves acquainted with the subject-matter of chemistry, and especially with our methods of arriving at the root-conceptions of structure and of properties as condition by structure. It is a serious matter that chemistry should be so neglected by physicists and that the votaries of the two sciences should be brought so little into communion.

The central luminary of our system, let me insist, is the element carbon. The constancy of this element, the firmness of its affections and affinities, distinguishes it from all others. It is only when its attributes are understood that it is possible to frame any proper picture of the possibilities which lie before us, of the place of our science in the Cosmos. But, as Longfellow sings of the sea in his poem, "The Secret of the Sea," "Only those who brave its dangers comprehend its mystery"—only those who are truly conversant with the root-conceptions of organic chemistry are in a position to attempt the interpretation of the problems of our science as a whole or even to understand the framework upon which it is built up. And yet we continue to withhold the knowledge of the properties of carbon from students until a late period of their development; indeed, when I insisted recently that organic and inorganic chemistry should be taught as one subject to medical students,* I was told that it could not be; that the attempt had been made with disastrous consequences. I trust that ere long the futility of such an attitude will be generally realized.

It is remarkable how much our conceptions are now guided by geometrical considerations. The development by van 't Hoff of the Pasteur hypothesis of geometrical asymmetry has been attended with far-reaching consequences during the period under review, the completeness with which the fundamental properties of the carbon atom are symbolized by a regular tetrahedron being altogether astounding.

Our present conception is that the carbon atom has tetrahedral properties in the sense that it has four affinities which operate practically in the direction of the four radii proceeding from the center toward the four solid angles of a regular tetrahedron.

More than an analogical significance—to use Larmor"s expression—must be accorded to this symbol on account of its remarkable accordance with the facts generally, whether derived from the study of asymmetric optically active substances or from observation of the activity of ring structures of various degrees of complexity. Nothing is more surprising than the completeness with which the vast array of facts included in organic chemistry may be ordered by reference to the tetrahedral model. In the future, when our civilization is gone the way of all civilizations and strangers dig on the sites of our ruined cities for signs of our life, they will find the tetrahedron and the benzine hexagone among the mystic symbols which they have difficulty in interpreting; if, like the ancient Egyptians, we made our tombs records of our wisdom, such symbols would long since have acquired sacred significance, and the public would probably have learned to regard them with awe and to respect them as totems. Chemists might at least wear them on aprons in imitation of the Freemasons; perhaps no two other symbols have so great significance—they reach into life itself.

It would seem that carbon has properties which are altogether special, the influence which it exercises upon other elements in depriving them of their activity is so remarkable. In their recent discussion of the relation of crystalline form to structure, in which valency is represented as a function of the volume sphere of influence exercised by an element, Barlow and Pope arrive at the remarkable conclusion that carbon is probably the only element the atom of which has a volume sphere of influence four times that of the hydrogen atom; although it combines with four atoms of hydrogen, silicon apparently has only half the volume sphere of influence of carbon. This may, in a measure, account for the very great dissimilarity in behavior of the two elements, which is most pronounced in their oxides, the single atom of carbon all but dominating two atoms of oxygen in carbon dioxide (which is consequently gaseous), while the atom of silicon in silicon dioxide in no way eclipses the two atoms with which it is associated but leaves both charged with residual affinity which enables them to form complex collocations of remarkable fixity in the fire. At bottom the differences between organic and inorganic nature are to be regarded as very largely the expression of this difference. Ropes of sand are proverbially treacherous; yet without sand, if silica had been a gaseous substance, our world might have worn a strangely different aspect.†

The mineral world apparently owes its rigidity to the fact that the metals and certain other elements are so imperfectly capable of dominating oxygen that oxides generally polymerise with great readiness, giving rise to substances which do not even fuse easily. The organic, on the other hand, appears to be plastic by reason of the close approach to neutrality which is conditioned by association with carbon.

Nothing is more striking than the remarkable diversity of properties manifest both in the materials which at present we are content to call elements and in the compounds formed by their interaction; the range of variation met with in the case of the compounds of carbon with hydrogen and oxygen alone is almost infinite. We are almost compelled to attribute this diversity more to differences in the complexity and structure of the molecules than to differences in their material composition. The chemist, of necessity, must be a dreamer, knowing as he does that things are not as they seem to be. But this is not sufficiently remembered; indeed, students are systematically trained up in at atmosphere of pretense. The beginner is allowed to regard elementary oxygen, for example, as a colorless gas, which is generally harmless until things are presented to it in a more or less heated condition, whereat it takes umbrage and burns them up. He would regard elementary carbon as a soft black substance, which if smeared on the face of the white man makes him look like a nigger, were it not that he also learns that at times it is the hardest and whitest substance known; of organic chemistry, which alone can give him honest ideas of carbon, he is not allowed to hear, as I have said. The sting of awakening conscience is salved by the introduction of a long Greek word when he is told that the two substances, soot and diamond, are allotropic forms of the element carbon; nevertheless, he regards them both as elementary carbon. Gradually, perhaps, he awakens to a sense of the wrong that he has suffered at the hands of his teachers, as he realizes that from no one substance can he gather what the properties of an element are, that after all the elementary substance is but an ideal—in other words, a mere concept. If appreciative, he then learns to think of the blandness of water, the sweetness of sugar, the sourness of vinegar, the causticity of soda, indeed every distinctive property of every known oxygen compound as more or less a property of, more or less conditioned by, the element of oxygen; he is brought back, in fact, to the position from which Lavoisier started, as he realizes that the oxygen gas which he inhales is not elementary oxygen; he can then perhaps appreciate the wonderful acumen which this greatest of chemical philosophers displayed when he wrote: "Nous avons donné à la base de la portion respirable de l'air le nom d'oxygène en le derivant de deux mots grecs *οξυς*, acide,

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* Abstract of a paper read before the British Association for the Advancement of Science.

† The Wilde Lecture, 1908. By Prof. Larmor, Sec. R. S. Manchester Literary and Philosophical Society Memoirs.

* "The Reform of the Medical Curriculum" (Science Progress, January and April, 1907).

† The solid model of silica which Barlow and Pope have constructed has very remarkable attributes, in that the oxygen atoms appear to be uniformly related and in intercommunication throughout its mass; so that a mass of silica, whatever its size, may almost be regarded as a single molecular complex. A similar view may be taken of the plastic metals such as those of the platinum group, gold, silver, and copper. Whether when rendered brittle by association with small amounts of impurity these are resolved into simpler molecular complexes or whether the molecules merely become separated by substances which promote discontinuity and brittleness, it is impossible to say at present. The cause of hardness in mineral materials is, however, a question of no slight interest and importance. The property is strikingly exemplified in the diamond. It is difficult to understand the intense hardness of this material, on the assumption that the diamond is composed of paraffinoid carbon—that is to say, carbon with all its affinities satisfied. At present we appear to have no clue to the manner in which affinity acts in promoting the formation of such solids. But it is obvious that all solids are possessed of some degree of "surface affinity," as they not only grow when placed in solutions but determine the separation of solid from a solution at a degree of saturation which is often considerably below that at which the solution is actually saturated with the substance; and such surface affinity, moreover, is selective, as the determinative effect is exercised only upon the substance itself or substances isomorphous with it—although exception must be made in favor of water, which all surfaces appear to attract. Sir James Dewar's observations on the condensation of gases by charcoal at low temperatures afford most striking illustrations of surface affinity.

γεινομαι j'èngendre, parce qu-en effet une des propriétés plus générales de cette base est de former des acides en se combinant avec la plupart des substances. Nous appelerons donc gaz oxygène la reunion de cette base avec le calorique." We have allowed a century to pass without recognizing the wonderfully accurate powers of prevision displayed by Lavoisier; what is worse, we have been so far led astray that instead of regarding oxygen as the characteristic and attractive elements in acids, hydrogen has been allowed to usurp the position: the extent to which the cult of the hydrogen ion now dominates the text-books is well known; in days to come, when the history of our times is written, it will be referred to as a remarkable example of chemical shortsightedness.

Names are needed for the elements which would serve to distinguish the ideal elementary substances from the forms in which they are known to us. No more appropriate name than oxygen could possibly be selected for the fundamental material; if the *gen* terminal could be applied to elementary materials generally, it would be an advantage; it would be easy, however, if this were done, to devise an appropriate name applicable to the active constituent of air.*

In 1885 I closed my address with a reference to the structure of the elements which implied that their behavior was that of compound substances; the feeling that this is the case has long been general among chemists. Our present attitude toward this problem is a curious one and not altogether satisfactory—it is impossible to deny that we have somewhat lost sense of proportion, even if our methods have not savored of the unscientific. The discovery of radium appears to have upset our balance—we have been carried away by the altogether mysterious and unprecedented behavior of this weird and wondrous substance. But may we not ask: Is radium an element? Has it not been too generally, too hastily assumed that it is? Little as we know of it, does not its behavior straightway outclass it as an element? Surely it does! Is not the established fact that an emanation proceeds from it, which in turn decomposes and gives rise to helium, a proof of its compound nature? Again, is the evidence of such a character as to justify us in asserting that uranium is the parent of radium? If it be such, must not uranium also disappear from the list of elements; must it not indeed be removed on the ground that it gives rise to uranium without any reference to its supposed relationship to radium?

The answers given to such questions must depend on our definition of an element? At present we seem to be without one.

The conception that the breakdown of radium is spontaneous and apart from all external impulse or control is also one which should be received with caution. There is reason to suppose that in all ordinary cases in which compounds undergo decomposition spontaneously, the decomposition is conditioned by an impurity; the effect, moreover, is usually cumulative. This is true of highly explosive substances, such as chloride of nitrogen and gun-cotton, for example. It might be supposed that something similar would happen in the case of radium—but apparently such is not the case; it is assumed that occasionally a molecule explodes spontaneously, not only without being incited thereto, but also without in any way affecting its neighbors.

The alternative explanation that radium in some way acts as a receiver, transforming energy from some external source to which ordinary substances fail to respond and being thereby stimulated to decompose, is at present out of favor, although perhaps more in accordance with its peculiar behavior.*

The liberation of helium as a product of radio-active change is in itself a significant fact, in view of the possibility that helium may be an element of intense activity. Nothing in connection with the problem is more surprising, however, than the apparent production, in course of time, of a whole series of degradation products which differ greatly in stability—such behavior is entirely without precedent and not at all becoming in elements.

No such remarkable and inspiring problem has ever before been offered for solution. We can only wonder at the results and admire the genius which some have displayed in interpreting them, Rutherford in particular. Yet outsiders may well hold judgment in suspense for the present: while it is permitted to workers to make use of hypothesis in every possible way in extending inquiry, the public are in no wise called upon to accept such hypothesis as fact.

But apart from the suggestion that elements may give rise to other spontaneously, we have been entertained of late with stories of elements being converted into others under the influence of the energy let loose by the breakdown of radium. There is reason, however, to suppose that the powers of radium may have been greatly overpainted; energy of almost any degree of intensity in the form of high-tension electricity is now at our disposal, and the effect which radium produces on living tissues, glass, etc., is of the same character as that effected by the Röntgen ray discharge, the only difference being that the effect is produced somewhat more rapidly; it is not to be imagined, therefore, that the discovery of radium has put any very novel intensity of power into our hands.

* In naming the inert gas in air, which he ultimately termed *azotic gas*, having proposed the name *azote* for the element, Lavoisier had in view as alternatives the terms *alcaligen* and *nitrogen*. As there was no proof that the element was a constituent of alkalies other than ammonia, he rejected the former name on the ground that it might convey too broad an impression; in course of time the latter is become the popular name, except in France, where motives of piety have prevailed; but the French practice has been justified by the universal use of the term *azo* in connection with many nitrogen derivatives.

Had Lavoisier realized that the alkalies and basic oxides generally owe their basicity to oxygen as much as acids and acidic oxides generally owe their acidity to oxygen—the one being oxygen tempered by metal, the other oxygen tempered by non-metal—as the number of basic oxides far outweighs the number of acidic oxides, he might well have chosen the name alcaligen rather than oxygen. The choice he made was a particularly happy one and striking evidence of his genius and sense of euphony—for oxygen is *par excellence* the acid-forming element and is most truly called *sour-stuff*, the stuff of which sour things are made—for whatever the properties of the initial oxide of a series, as the proportion of oxygen is increased, the acidic qualities are invariably strengthened.

The choice of a terminal connoting the elementary radicles which would be applicable generally and also acceptable is very difficult. If usage do not forbid change, probably our ears will decline to allow us to be systematic. The terminal *gen* is not applicable to many present names. In the interest of euphony, exception may be taken to the adoption of *ion* as a final syllable. In English ears most of the words with this ending have an ugly sound if pronounced so as to make it significant; moreover, our object is to secure a term which is applicable to the elementary material, whatever its state; the term ion is suggestive of a particular state—a state of chemical activity; and at present there is no agreement as to the nature of an ion. The terms atom, radicle (simple and compound), ion and molecule now all have their separate meaning and value and are indispensable.

The only terminal which seems in any way likely to be generally satisfactory in use is the terminal *yl*, which is already applied to organic radicles; its use might well be extended to radicles generally.

* I may here put on record the opinion Lord Kelvin expressed on this question in a letter to me dated September 13th, 1906:

"Ever since, nearly four years ago, we heard of the hundred calories per hour given out by radium, I have had on my mind the question of some possible mechanism such as that which you suggest by which energy from surrounding matter (far or near) could automatically come into radium to supply the energy of the heat which it gives out. The more I think of the question the less I see of that possibility. At present I can see nothing else than that the energy given out is taken from a previously existing store of potential energy of repulsive force between separable constituents of radium.

"The 'disintegration of the radium atom' is wantonly nonsensical. It is nonsense very misleading and mystifying to the general public, because, if what is at present called radium can be broken into parts, it is not an atom.

"'Energy of an atom' implies a thorough misunderstanding of the meaning of the word energy, which is capacity for doing work.

"I admire most sincerely and highly the energy of the workers in radioactivity and the splendid experimental results which they have already got by resourceful and inventive experimental skill and laborious devotion. I feel sure that as things are going on we shall rapidly learn more and more of the real truth about radium."

HEATING BY FRICTION.

EVERY engineer is but too familiar with hot bearings. No one, be he engineer or scientist, knows why they get hot. Benjamin Thompson, Count Rumford, was the first to prove that friction produced heat. His experiments are detailed in a paper read before the Royal Society in 1798. It was entitled "An Inquiry Concerning the Source of Heat which is Excited by Friction." Before that date "Caloric" was regarded as a kind of fluid which, already in the metals, was rubbed out or squeezed out by friction. That friction will produce heat seems to have been known even by prehistoric man, certainly by savages even of a low type. The fact remains that the way in which work is transformed into heat is as little understood as the converse operation. If we examine what has been written on the subject, we shall find that for the most part authors deal with lubrication and lubricants. Others advance theories concerning the assumed interlacing of the surfaces in contact. But no one has done more than attempt to arrive at some explicit statement of the actual *modus operandi* by which a badly-lubricated bearing becomes hot.

There are some special cases of heating which are very difficult to explain. That is to say, the performance of the materials concerned is apparently entirely abnormal. It may be taken for granted that heat is conducted at some fixed rate through a metal. Indeed, tables of these rates can be found in numerous text-books. Again, it is always assumed that for some reason the amount of pressure forcing two rubbing surfaces against each other is a powerful factor. Its influence is usually explained by saying that there is a certain pressure beyond which the oil is squeezed out and metallic contact obtains. An old theory was that the molecules of the lubricant acted as miniature roller bearings. It is now held that the lubricant only acts by preventing metallic contact. Be this as it may, heating by friction not infrequently manifests phenomena which, as we have just said, it is difficult to explain. Such cases come repeatedly under the notice of marine engineers. A piston-rod is running, so far as is known, quite cool. Suddenly, without warning, it becomes bright red-hot at one side, and at one side only. No attempt can be made to cool the rod quickly. It has been bent by the local heat, and will remain bent if water is put on it. The engine must be slowed down. Then the heat will, so to speak, run round the rod, which cools down behind the passing heat wave. The rod is never red-hot all round at once. Why does such a bar of polished steel, six or eight inches in diameter, running in a hemp packing—heating will take place even more readily with hemp than it will with soft metal, or gauze rings—become red-hot in a few seconds under the eye of the greaser? We once saw a compound locomotive run into a station with the oil on the guide bars flaming. No heating had taken place during a run of some 40 miles at a very high speed. When the steam was shut off the oil fired—that is to say, in about one-fourth of a minute the piston rod became bright red-hot. It then bent and seized the brass gland of the stuffing-box, breaking it in two. We have seen a heavy wall bearing in a mill at one moment quite cool, the next molten brass was running down the wall. This instantaneous heating is, indeed, well within the experience of most engineers. It by no means represents all that might be said concerning the abnormal heating of bearings. The chief engineer of a very large mail steamer told us recently that he had at one time a remarkable experience. He was serving as second in a somewhat similar ship. She had new triple-expansion engines fitted with steam jackets. The chief wished to test the value of the jackets, and to that end ran sometimes with steam in the jackets, and sometimes shut out of them. It was found that the high-pressure piston rods always ran cool when the jackets were in use, and always heated, no matter what was done when the jackets were out of use. The heating in this case was not sudden, but gradual and steady. It is so difficult to trace any connection here, that were it not that the evidence is irrefragable, we would not have credited the story. But it is well to remember that apparently minute conditions suffice to bring about excessive frictional heating. Thus in cold drawing tubes a very minute speck of hard material in the die will very greatly augment the resistance, and set up heating. The only evidence left on the tube is probably a scratch which can hardly be seen without a magnifying glass. The opening or shutting of an engine-house door has been known to settle whether the crankshaft will run cool or hot. It is quite possible that locomotive crank pins would not run cool if they were boxed up so that a current of cold air could not get at them.

It may with some truth be observed that cases such as those of which we have written are very unusual, and that the conditions which give us cool bearings of all kinds are well understood, and need no further investigation. But the sudden heating of piston rods and bearings is, after all, not very exceptional. They are events, at any rate, which the marine engineer on watch is always anticipating; and even if this were not so, this fact that an enormous conversion of work into heat can be brought about by apparently entirely inadequate means is an extremely interesting physical truth. We have got into the habit of regarding much that is really complex and puzzling as a matter of course. No one attends to what is going on day after day. Abundance of such every-day physical facts remain not only unexplained, but without any attempt being made to explain them; and yet it is certain that in the past some of our greatest advances have resulted from the careful investigation of common and well-known things. The sudden heating of a big steel bar by rubbing against wet hemp rings is, we think, a thing for which it would be worth while to find an explanation. The end is the conversion of work into heat; the means by which the conversion is effected seems to be wholly inadequate to that end.—Engineering.

It is stated in a consular report that milking machines have now been introduced into Denmark. Among these, one is described as being a thoroughly efficient machine, though it works on the principle of continuous suction. The actual time taken by this machine was 20 minutes for 15 pounds of milk. Other machines, working by combined pressure and suction, occupy, on the average, about eight minutes per cow. An Australian milking machine is also reported as having given satisfaction. The cows adapt themselves very quickly to it, and no udder disease has been noticed in places where the milker has been employed. A man with two double machines can milk fifty cows in two hours—that is to say, that the machine is three to four times as quick as ordinary hand-milking.

ENGINEERING NOTES.

Experiments with rubber asphalt roadways covering a period of six years are reported to have shown very satisfactory results. Rubber asphalt is claimed to be more plastic and more adhesive than pure asphalt and resists higher temperatures. This product, which is manufactured under a patented process, permits cold applications of the asphalt, which are said to possess all the advantages of hot compressed asphalt without its drawbacks.

Five concrete switchboards, each 76 feet long, and containing numerous pigeon-hole compartments for instruments that must be isolated, have been built. The main walls are 9 inches thick, and the barrier walls for the compartments from 2 inches to 7½ inches, depending on their position and the weight of the apparatus on the horizontal slabs which they support. The boards were built in 16-foot sections with felt expansion joints, and contain only 92 cubic yards of concrete, though the superficial area is over 42,000 square feet. The material was a 1 : 2 Portland cement mortar.

A ballast wagon of peculiar design, which is intended to prevent the sticking of the load, has been tried on the Duluth, Missabe and Northern Railway for handling ore. The body or box is supported by trusses on either side, and consists of two parts, hinged together at the top at the mid-length of the wagon. Under each end of the body is an air cylinder for elevating the end, so that the two portions separate at the middle and the contents are discharged between the rails. The maximum width of opening is 5 feet, with the two parts inclined at an angle of 50 deg. The wagon is 22 feet long, weighs 17 tons, and has a carrying capacity of 50 tons.

A breakwater which, when completed will be some 10,000 feet in length, is now in course of construction at Hilo, in the Island of Hawaii, to protect shipping from the heavy seas that sweep from the northeast. At present some 400 feet have been completed, and under the existing contract it is estimated that by the middle of next year a length of some 3,000 feet will be in position. The material used for construction is a basalt rock resembling heavy granite, which is quarried some 25 miles away, and transported to the work under contract with the Hilo Railway Company. According to the specifications, from a depth of 3 feet below the water-line to the top, bowlders of not less than 8 tons in weight are to be used. The contractors are confident that the rock in question, which weighs 165 pounds to the cubic foot, will resist any action of the waves, without the use of cement to bind it.

That coal dust is a most dangerous thing in a mine has been proved by experiments in this country and in France, and the dust produced by mechanical coal cutters is a drawback to be considered. In a paper before the Coal Mining Institute of America, Mr. G. R. Wood gives some figures obtained in actual practice. The dust was measured after passing through a 40-mesh screen, and on the basis of each square foot undercut. At one colliery the dust produced was 1.8 pounds with hand cutting, 4.58 pounds with the puncher machine, and 1.48 pounds with a chain-cutter machine. At another colliery the figures for the puncher and chain machines were 6.18 pound and 2.43 pounds respectively, while at a third colliery the corresponding figures were 6.18 pounds for the puncher and 2.43 pounds and 2.51 pounds for chain machines. It is unfortunate that figures for hand-won coal were not obtained for the last two mines, although the relative dust-producing qualities of the various methods are probably similar with different qualities of coal. The chain machine does not seem to differ much from hand winning, but the puncher machine is clearly a serious dust producer, and in dry or fiery mines this is a point worth remembering.

The vicinity of Broken Hill, in Australia, contains millions of tons of zinc ore, consisting chiefly of zinc sulphide or blende, containing lead, much iron, and a large proportion of silver. Until very recently, owing to the lack of economical methods of treatment, these ores were not worked, except at the Mortagne mine, which was operated by a German company. In 1905 the Broken Hill Company commenced operations at Port Piree, using a recently-developed method. At first the results were very unsatisfactory, owing to lack of experience, labor troubles, and the poor quality of the fireclay employed in the construction of the furnaces. In 1907 a mining engineer, imported from Germany, assumed charge and at once reconstructed the whole plant, a good refractory clay having fortunately been found in the vicinity; 500 tons of clay were used in the construction of the furnaces, the retort chamber of which is 30 feet long, 13 feet wide, and 8 feet high, and contains 144 retorts. According to reports published in certain newspapers, 100,000 tons of zinc are produced yearly at Broken Hill, while the annual output of the next largest establishment in the world is only 60,000 tons. If this statement is correct, the Australian production amounts to one-tenth of the world's production of zinc.

ELECTRICAL NOTES.

At Yokkaichi, Japan, the electric-light company has installed a 750-kilowatt Westinghouse turbo-alternator in its Miye Ken plant, near Nagaya. The turbine operates at 200 pounds steam pressure, exhausting into a vacuum of 27 inches. Three-phase 60-cycle currents at 2,200 volts, for lighting and power purposes, are supplied by the new generator. Three 55-horse-power Westinghouse gas engines have been installed by the Furawaka Coke Works, of Tokio, to operate a coal-washing plant. These engines will use as fuel the surplus gas from the coke ovens, having an average calorific value of 460 B. T. U. per cubic foot.

Tenders have been recently advertised for by the Navy Department of the United States for the construction of the highest tower wireless telegraph system yet devised. It is proposed to build at Washington a concrete tower which will rise 600 feet, overtopping the Washington Monument by 45 feet. Installations will also be made on board the various vessels of the fleet, so that it will be possible to telegraph 3,000 miles seaward and from vessels to land a distance of 1,000 miles. The Navy Department has been working on the scheme for about two years. An appropriation of $70,000 for the construction of the tower and of $100,000 for the purchase of wireless instruments is available.

A series of tests on the absolute efficiency of light production of the common incandescent lamps was made in 1908 at the University of Vermont, under direction of Prof. W. H. Freedman. These are reported in the Vermont Engineer. A method of finding the ratio of light radiation to the total was adapted, using a thermopile and galvanometer. One face of the thermopile was carefully protected from temperature changes, and the other was exposed to the lamp under test. The galvanometer was in series with the thermopile alone. A double screen of heat insulating material was placed between the lamp and thermopile, but the screen contained openings which could be opened and closed by slides from a distance. A glass cell, carrying water, was used between the lamp and screen to cut off the non-luminous rays when desired. The first kick of the galvanometer, on opening the screen, was taken as proportional to the radiation received by the thermopile. The ratio of kicks under exposure to luminous and to total radiation was taken as the radiant efficiency of the lamp under study. No correction was made for the absorption or reflection of luminous rays by the glass cell.

Attention is drawn by J. F. van Lonkhuyzen in the Elektrotechnische to a simple source of error in electric instruments which is frequently overlooked, though quite understood. It is the static charge of the cover-glass of the instrument. The longer the pointer, the nearer it is to the glass, the drier the atmosphere, and the feebler the discharge force of the instrument, the greater will be this error. By drawing a piece of soft leather across the glass of a galvanometer Lonkhuyzen produced deflections up to 5 per cent. In a dry, warm room instruments went wrong by as much as 20 per cent when touched with the dry hand. These deflections are not lasting, but it may be an hour before the pointer indicates correctly again. When making comparisons with mirror instruments the error may become pronounced, because the glass is cleaned to wipe off the dust. Particular care has to be exercised in this respect in the workshop, especially with suspended instruments. There is, fortunately, an easy preventive—breathing upon the glass. Faulty indications may also result when the instrument is joined to the secondary of an insulated transformer. The secondary may have a static charge sufficient to upset the instrument.

An electrolytic hydrogen plant has been erected by the United States Signal Corps, at Fort Omaha, in Nebraska, in connection with a large new balloon house which has been established there for experiments with dirigible and other balloons. According to the Electrical World, a 200-kilowatt motor generator, taking current from an electric light and power company in the neighborhood, has been erected. This converts the alternating supply to continuous current at from 66 to 110 volts. The hydrogen is generated by electrolysis in cast iron cells containing caustic potash electrolyte. There are 30 of these cast-iron electrolytic cells, all connected in series. The voltage required varies according to the temperature of the cells, hence the wide range of voltage for which the generator is designed. The operating voltage when the cells are warmed up is 85 volts for the 30 cells, or 2.8 volts per cell. The cells are rated at 1,500 amperes. The output of hydrogen at 1,500 amperes is about 23 cubic feet of gas per hour, or 690 cubic feet for the 30 cells. Both of the electrodes are of iron. The iron case of the cell forms the negative electrode from which the hydrogen is obtained. The positive electrode, which gives off oxygen, is in the shape of an iron cylinder in the cell. Hydrogen gas, which collects above the negative electrode, is taken to a 50,000-cubic-foot gasholder.

TRADE NOTES AND FORMULÆ.

Steel wool is used as a substitute for sand, emery or glass paper, for rubbing down wood, brass or other alloys, as well as for rubbing off varnished work and oil-painted surfaces. Steel wool consists of the finest possible steel shavings, and the finer kinds present the appearance of dark-gray wool. It feels like wool and is exceedingly light.

Steel-gray Color for Copper Alloys.—For preparing the stain use 1,000 parts hydrochloric acid and 125 parts nitric acid, dissolve in the mixture 42.5 parts of arsenic, and finally add, gradually, 42.5 parts of iron filings. The objects are cleansed by scrubbing in warm water and then, without touching them again with the fingers, suspended in the stain, in which they may remain for about 5 minutes. Tubing is made most attractive, if first polished on the lathe with emery paper and then immediately placed in the stain. The objects, after they have been wiped off with soft linen cloths, are coated with white (colorless) spirit varnish.

Carpet Soap.—For this purpose a soap is adapted that dries very hard and friable, and at the same time is free from alkali and fat. It is best to prepare a concentrated aqueous solution of a pure soda grain soap, free from rosin and made from the fixed fatty acids or from very hard tallow; to make a stiff suds of this, spread it evenly over the surface of the carpet and allow it to dry completely. The water evaporates and the dry soap particles form a hard coating, which retains all the dust on the surface. If the carpet is then thoroughly beaten on the reverse side, the soap will fall off, or it may be removed by brushing.

Soap varnish is known for various properties that make it very valuable for certain purposes: notable among these qualities is its absolute unchanging nature in water and the considerable elasticity which this very cheaply-made varnish possesses. It is easiest made in the following manner: Good tallow grain soap is boiled with rain water, so as to produce a clear solution, which, while hot, is filtered through several closely-woven cloths. Afterward the solution is again heated and diluted with an equal volume of rain water, then add a solution of alum, prepared boiling hot, until a precipitate of oleate of alumina is no longer formed. The precipitate is allowed to settle, the supernatant fluid is poured off and the precipitate washed out in boiling water. The precipitate is then dried and heated in a pot in the water bath until it assumes a translucent appearance. In the meantime, in a pot, oil of turpentine is heated to near the boiling point and the alumina soap added until a solution is obtained of the consistency of thick varnish.

Satin White (for use in place of permanent white in colored paper and paper making).—I. Most expensive kind: 100 parts of chloride of magnesium dissolved, hot, in 200 to 300 parts of water and then allowed to flow, through a linen filter, into a large tub. Into this solution of chloride of magnesium, constantly stirring, pour a hot solution of soda, as long as the precipitation of carbonate continues, which can readily be discerned by the flocculent deposit. In a smaller vessel, dissolve 75 parts of soda in hot water, filter through linen into a roomy tub and constantly stirring, add a solution of 100 parts of sulphate of alumina. The hydrate of alumina thus obtained is washed out once or twice, and after this, as soon as all the magnesium carbonate in the first vessel is precipitated, it is added to the contents, stirring vigorously the while. Finally, the deposit is strained out and thoroughly pressed. II. Medium kind: 100 parts burned lime are ground as fine as possible in a wet mill, mixed into a finely comminuted lime milk and washed through a fine sieve into a tub. In a smaller vessel, dissolve about 45 parts of soda in hot water, and pour the solution, stirring actively all the time, through a sieve into the lime milk. The principal object to be attained is to work as thin as possible. In another vessel, dissolve 100 parts of sulphate of alumina in hot water, and add this solution, stirring continuously, to the contents of the first tub. After stirring for a time, it is washed out several times, filtered and thoroughly pressed. III. Cheap sort is produced like II, only one must use from 130 to 140 parts of burned lime.

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